

THE CONTRIBUTION OF THE ECHOCARDIOGRAPHY IN EVALUATING THE PATIENTS WITH SECONDARY CHRONICAL COR PULMONALE COPD

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Abstract: The classic non-invasive imagistic techniques which evaluate the structure and function of the right ventricle (RV) in patients with COPD (chronic obstructive pulmonary disease) shows important limitations caused by its complex geometry. They have a special importance in following the evolution of the illness and the remodelling of the RV. Among the impediments in the classic echocardiography evaluation of the right heart we can distinguish the difficult visualization of the front RV wall, because of its retrosternal position, a difficult acoustic window in 10-20% of cases, diminished accuracy and reproducibility of the measurements and ejection fraction of the right RV as a consequence of its complex geometry. The calculation of the right RV volumes and ejection fraction do not represent ideal methods for evaluating its function. The regional movement of the myocardial wall detected through the M-mode echography and the tissue Doppler imaging (TDI) velocities seem to be the best methods used in the actual practice. The evaluation of the RV function at patients with COPD is important because the presence of the RV insufficiency has a reserved prognosis.

Cuvinte cheie: BPOC – cord pulmonar cronic – ecocardiografie 2D – Tissue Doppler

Rezumat: Tehnicile imagistice non-invasive clasice care evaluează structura și funcția ventriculului drept la pacienții cu BPOC (bronhopneumopatie cronică obstructivă) prezintă limitări importante cauzate de geometria complexă a acestuia. Acestea prezintă o importanță deosebită în urmărirea progresiei bolii și a remodelării VD (ventriculului drept). Dintre impedimentele evaluării ecocardiografice clasice a cordului drept se disting vizualizarea dificilă a peretelui anterior al VD cauzată de situarea acestuia retrosternal, fereastră acustică dificilă în 10-20% din cazuri, acuratețe și reproductibilitate diminuate ale măsurătorilor și fracției de ejeție a ventriculului drept ca și consecință a geometriei complexe a acestuia. Calcularea volumelor și a fracției de ejeție a ventriculului drept nu reprezintă metodele ideale pentru aprecierea funcției acestuia. Mișcarea regională a peretelui miocardic detectată prin ecografia mod M și velocitățile tissue Doppler par a fi cele mai bune metode utilizate în practică actuală. Evaluarea funcției ventriculare drepte la pacienții cu BPOC este importantă deoarece prezența insuficienței ventriculare drepte are un prognostic rezervat.

SCIENTIFIC ARTICLE OF BIBLIOGRAPHIC SYNTHESIS

The echocardiographic evaluation of the patients with BPOC represents a challenge because of the technical difficulties which emerge with the evolution of the pulmonary illness, but also because of the reduced sensitivity of the classic non-invasive techniques in detecting the incipient modifications of the right ventricular structural and functional alteration.

The 2D echocardiographic evaluation

The 2D echocardiography is often difficult from a technical point of view in patients with COPD because of the increase of the retrosternal space secondary to hyperinflation and to the difficult transmission of ultrasounds, but an adequate examination can be obtained in 80% of patients. The position of the right ventricle next to the stern, as well as its complex geometric shape represent some of the limits of the 2D echocardiography.(1)

In case of existence of the chronic cor pulmonale, signes of chronic pression overload are frequent in the RV. Typical signes of cor pulmonale are the increase of the right ventricle and atrium dimensions with normal or reduced left cavities. As this overload progresses, the thickness of the right ventricle wall increases and the paradoxical systolic motion of the interventricular septum appears. In more advanced stages the

right ventricular dilatation takes place, and the septum shows abnormal diastolic applatization. In extreme cases, the septum can even swell into the left ventricular cavity during the diastole causing a diastole volume reduction in the left ventricle responsible for the decrease of its rate. The interventricular septum (IVS) thickens leading to an over-unit value of the relation IVS/posterior wall of the left ventricle as an answer to the pressure overload. The left ventricle has the shape of the letter D with the reduction of the systolic and diastolic volume, but with the preservation of the global systolic function.(2)

In patients with severe BPOC and pulmonary hypertension (PHT) at rest a right and left ventricular diastolic dysfunction secondary to ventricular interaction was proven, caused by the presence of the common interventricular septum and pericard, while the patients with COPD without PHT have a normal right and left diastolic function.(3)

An estimate of the right ventricle contractility can be obtained by measuring the end diastolic and end systolic dimensions of the right ventricle. The right ventricle shortening fraction can be calculated with the help of the formula

$$\text{Shortening fraction} = \frac{\text{RVEDD} - \text{RVESD}}{\text{RVEDD}}$$

Unfortunately, the irregular shape of the right ventricle does not offer the possibility of an accurate measurement. High variability exists between examiners and

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between examinations, which is why it cannot be used as a safe parameter for the estimation of the RV function.

Burges et al evaluated the prognosis importance of the RV function echocardiographic estimation at 87 patients with COPD. These authors demonstrated that the end diastolic diameter of the RV as well as the velocity of the late diastolic filling of the RV are independent predictors of survival. These indexes have a high feasibility, even in patients with severe hyperinflation.(4)

The association of COPD with the coronary disease is frequent and presents important therapeutical implications. The manner in which the diastolic dysfunction of LV influences the RV function remains a controversy. In patients with COPD that have a coronary disease with a decrease of the LV systolic function (LVEF under 45%) that were performed a classic echocardiographic examination, a positive correlation between E/e as a parameter which evaluates the left ventricle diastolic dysfunction and the Tei index as a parameter which evaluates the function of the right ventricle came forward.(5)

A history of the long-time smoking in patients with COPD increases the risk of the concomitant presence of the coronary disease. Apparently, a positive correlation between FEV1/FVC (forced expiratory volume in 1 second/forced vital capacity) and the ejection fraction of RV (RVEF) exists in patients with COPD without coronary affection, and a reversed correlation between FEV1/FVC and the medium pulmonary arterial pressure (PAPm) as well as in the isovolumetric relaxation time of the left ventricle. Medium PAP apparently correlates reversed to RVEF. At patients with COPD and the co-existing coronary disease with a normal systolic function of the left ventricle presents a reversed FEV1/FVC correlation and medium PAP and a more reduced RVEF than the patients with no coronary disease. These data suggest that the diastolic dysfunction of the right ventricle takes place before the beginning of the left ventricular insufficiency in patients who associate the two comorbidities, which is probably due to the isolated and long-term evolution of COPD.(6)

M mode echocardiography

TAPSE (tricuspid annular plane systolic excursion) represents a sensible prediction element whereas the functional status of the right ventricle is concerned. Patients with COPD and PHT with no clinical signs of right cardiac insufficiency were monitored with the M-mode echocardiography for one year regarding TAPSE, eco2D, whereas the measurements of the RV are concerned and the systolic pressure of the right ventricle was calculated through the Doppler technique. TAPSE proved to be an indicator easy to obtain and sensible, with an important role in the prediction of the evolution towards right cardiac insufficiency in patients with COPD and PHT. (7)

Recent studies evaluated comparatively TAPSE with RVEF obtained by magnetic resonance imaging for the purpose of evaluating the systolic function of the right ventricle. The contractility of the RV represents an important prognosis function for the evolution of the chronic cor pulmonale. It was proven that TAPSE represents an element which is easy to obtain and safe whereas the systolic function of the right ventricle is concerned, elements of uncertainty regarding the intermediary values of TAPSE remaining. More than that, TAPSE cannot be considered an eligible method when a precise evaluation of the RV contractility is wanted.(8)

Myocardial Tissue Doppler Imaging

TDI is a relatively new echocardiographic method used in evaluating the myocardial function. This method is available in most modern ultrasound devices and can offer accurate information about myocardial movement during the cardiac cycle. The systolic and diastolic evaluation of the right

ventricle free wall and the tricuspid valve ring through the tissue Doppler method can be correlated to the hemodynamics and function of the right cavities and can be useful in the early detection of the right RV dysfunction, which can have an important impact upon the treatment and prognosis.

Unlike the traditional pulsed Doppler echocardiography, which detects the high velocities with low amplitude, TDI detects the low velocities with high amplitude. In order to express the tissue velocity two relatively simple alterations of the Doppler signal are necessary. Tissue velocities can be expressed with pulsed spectrum or color coded Doppler in M-mode, 2D or Doppler signal. It is supposed that TDI is less dependent of preload than the traditional pulsed Doppler technique. The typical registration displays five main components of the velocity and three time intervals which can be measured. Any prominence of the asynchrony appears as incorrectly timed segmental movements. The right ventricular myocardial velocities are obtained in an incidence of apical four chambers, and the copies are most accurately obtained from the level of the segments of the tricuspid ring, basal and medium of the right ventricle free wall. The pulsed TDI is a more simple method and also easier to use, with a high temporal resolution. The great disadvantage of this method is the low space resolution secondary to the cardiac movements, because the beat volume is fixed and the apical velocities from the apical four chamber projection are difficult to measure. Recent studies have proven that the pulsed tissue Doppler echocardiography is a reliable diagnosis method in establishing the right ventricular dysfunction. This method can also be useful in establishing the high pressure in the pulmonary artery. In patients with severe pulmonary hypertension and increased pulmonary vascular resistance measured through invasive methods a very prolonged isovolumetric relaxation time of the right ventricle (RV-IVRT) was proven, correlated with PAP (pulmonary arterial pressure) measured through the right heart catheterization and the systolic pressure of the right ventricle measured by echocardiography. In conclusion, the RV-IVRT measured by TDI represents an important marker of the right ventricular pressure increase, respectively the pulmonary arterial pressure increase. (9)

Recent studies, through the use of the pulsed tissue Doppler echography, evaluated the diastolic function of the right ventricle in patients with COPD with increased pulmonary arterial pressure in comparison to a control group. A 2D echography was performed and the following TDI parameters were measured: the e wave (maximum early diastolic velocity), eDT the deceleration of the e wave, the a wave (maximum late diastolic velocity), the s wave (maximum systolic velocity) and the duration of the s wave, the isovolumetric relaxation time (IVRT) and the isovolumetric contraction time (IVCT). The conventional measurements between the two groups were similar, while the TDI parameters of the right ventricle were different from those of the control group. The maximum early diastolic velocity (e wave) and the s wave measured in the left parasternal long axis were larger in patients with COPD. The IVRT measured at the apex, the medium area and the right ventricle ring and the eDT measured from tip of the right ventricle in apical four chamber were also significantly high at patients with COPD, concluding that TDI is a sensible diagnosis method in evaluating the diastolic function of the right ventricle in comparison to the conventional echocardiography, and the IVRT and the right ventricle wall represent significant parameters in evaluating the diastolic dysfunction of the right ventricle. The IVRT of the right ventricle measured through TDI represents an important parameter in estimating the increased pressure in the right ventricle in PHT. (10, 11)

The myocardial performance index (MPI) or Tei index

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represents a systolic and diastolic index, useful in the global evaluation of the right ventricle function without any geometric implication. Tei index allows for the identification of the right ventricle dysfunction in patients with COPD for whom the conventional methods could not be used, correlating functional respiration tests and with arterial gasometry. Patients with COPD and PHT usually present right ventricular diastolic dysfunction.(12, 13)

In patients with moderate and severe COPD and normal pulmonary pressure it has been proven the presence of the pulmonary vascular resistance increase secondary to some subclinical pulmonary vascular modifications, not followed by right ventricular dysfunction. The transthoracic echocardiography allowed for the evaluation of the 2D echocardiographic parameters (the dimensions of the chambers and the ejection fraction of the right ventricle), as well as the Doppler parameters (the degree of tricuspid regurgitation and the maximum velocity). PVR (pulmonary vascular resistance) was calculated with the help of the maximum velocity of tricuspid regurgitation and RVOT TVI (isovolumetric relaxation time of the right ventricle entrance tract). The right ventricular dysfunction was evaluated by the tissue Doppler method. The subclinical increase of PVR is frequent (in 60% of patients with COPD) and is not correlated to the severity of flux limitation, possibly representing a potential therapeutic target before developing PHT (pulmonary hypertension) and the right ventricular dysfunction.(14)

CONCLUSIONS

The accuracy evaluation of the right ventricular function remains limited despite of the rapid development of the echocardiographic techniques. The calculation of the volume and ejection fraction of the right ventricle are not election methods, as they take a long period of time. The measuring of the myocardial wall motion and the transvalvular velocities at the level of the entrance and exit tract of the RV through M mode and the tissue Doppler velocities are probably the most objective and reproducible methods to use in the medical practice. Since the right ventricular function was proven to be a sensible predictor of tolerance to effort and prognosis of the patient with COPD, the identification of the most sensible functional marker for evaluating the right ventricular dysfunction has a special clinical importance.

REFERENCES

1. Klinger J R, Hill N S. Right ventricular dysfunction in chronic obstructive pulmonary disease. Evaluation and management. CHEST 1991;99:715-723.
2. Bossone E, Bodini B D, Mazza A, Allegra L – Pulmonary Arterial Hypertension the Key Role of Echocardiography. Chest. 2005 May;127(5):1836-43.
3. Bianchi M, Zuccarelli A, Castiglioni M G. Left and right ventricular diastolic function in patients with chronic obstructive pulmonary disease. Eur J Echocardiography Abstracts Supplement, December 2003, S75.
4. Burgess M I, Mogulkoc N, Bright-Thomas RJ, Bishop P, Egan JJ, Ray SG. Comparison of echocardiographic markers of right ventricular function in determining prognosis in chronic pulmonary disease. J Am Soc Echocardiography. 2002;15:633–9.
5. Gertsen MA, Zuiko AN. Cardiac function in patients with chronic obstructive pulmonary disease and co-existent coronary heart disease. Eur J Echocardiography. Abstracts Supplement, December 2008, S84.
6. Gertsen MA. Left and right ventricular functional interdependence in chronic obstructive pulmonary disease patients having coronary heart disease with depressed left ventricular systolic function. Eur J Echocardiography Abstracts Supplement, December, 2008, S 84.
7. Polikina OA, Vikentye VV. TAPSE as a predictor of the right heart failure in patients with pulmonary hypertension. Eur J Echocardiography Abstracts Supplement, December, 2009.
8. Catalano O, Moro G, Mussida M, Antonaci S, Frascaroli M, Baldi M, Cobelli F. How much precise is tricuspidal annular plane systolic excursion in assessing right ventricle systolic function? A comparison with the gold-standard cardiac magnetic resonance. Eur J Echocardiography Abstracts Supplement, December 2009.
9. P Podolec, M Kaznica-Wiatr, R Wilkolek, M Kroshin, M Hlawaty, W Tracz. Relationship between the right ventricular isovolumetric relaxation time and pulmonary artery pressure in patients with pulmonary arterial hypertension. Eur J Echocardiography Abstracts Supplement, December 2005, S26.
10. A Atar, A Özsancaç, I Atar, O Gülmez, S Savas, F Eyüboğlu, H. Müderrisoğlu. Evaluation of right ventricular diastolic function in patients with chronic obstructive pulmonary disease using pulsed Doppler tissue echocardiography. Eur J Echocardiography Abstracts Supplement, December 2003, S134.
11. J U Voigt, G Wasmeier, U Nixdorff1, FA Flachskampf, G R Sutherland, W G Daniel. Right ventricular IVRT measured by tissue Doppler may provide an alternative estimate of right ventricular pressure. Eur J Echocardiography Abstracts Supplement. December 2003, S134.
12. M Bianchi, MC Maida Giovacchino Castiglioni. The value of Tei-index for the echocardiographic diagnosis of right diastolic dysfunction in patients with chronic obstructive pulmonary disease. Eur J Echocardiography 2004; S1–S36.
13. A Onbasili, M Polatly, T Tekten, C Ceyhan1, M Kaya1. Assessment of right ventricular functions with myocardial performance index method in patients with chronic obstructive pulmonary disease. Comparative study with healthy subjects. Eur J Echocardiography Abstracts Supplement, December 2003, S73.
14. N Mai, L Garske, T H Marwick. Subclinical pulmonary vascular changes occur without pulmonary hypertension or right ventricular dysfunction in moderate to severe chronic obstructive pulmonary disease - Eur J Echocardiography Abstracts Supplement, December 2006, S203.