Non Invasive Measurement Of Right Ventricular Function In Pulmonary Hypertension: Study From A Tertiary Care Centre In Gujarat

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Abstracts: Introduction: Pulmonary hypertension (PH) is the disease of pulmonary circulation with consequent impact on right ventricular (RV) function. 2D Echocardiography is an easily available non-invasive method for PH detection. RV bears the major brunt of PH; and assessment of RV dysfunction with available clinical and investigative parameters is relatively complex. We tried to analyse RV function with reference to PH severity by 2D Echocardiography and tissue Doppler imaging. Methods: 60 patients with PH defined as 2D echocardiographic RV systolic pressure (RVSP) of >=40 mm Hg were recruited prospectively. Various 2D Echocardiographic parameters were analysed. RV ejection fraction (RVEF) was calculated by volumetric assessment by method of disc. Tissue Doppler imaging was performed to measure tricuspid annular systolic excursion (TASE). RVEF less than 35% and TASE less than 0.100 m/s were considered as abnormal RV function. Correlation coefficients (r) were calculated for the relationship between RVSP, a measure of PH severity; and RVEF and TASE, the measures of RV dysfunction. Results: 51.7% patients had mild PH defined as RVSP between 40-55 mm Hg. There was significant ($p<0.0001$) negative correlation between RVSP and RVEF with $r=-0.5670$. There was significant ($p<0.001$) negative correlation between RVSP and TASE with $r=-0.4166$. there was significant ($p<0.0001$) positive correlation between RVEF and TASE with $r=0.5821$. Conclusion: RVEF and TASE are the markers with significant value in identifying RV dysfunction and in prognosticating a patient with PH; and can be measured by easy, noninvasive and cost effective tool like 2D Echocardiography and Tissue Doppler Imaging. [Thanky A Natl J Integr Res Med, 2018; 9(6):8-12]

Key Words: Pulmonary hypertension, Right ventricular function, Echocardiography.

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Introduction: Pulmonary hypertension (PH) is the disease of pulmonary circulation with consequent impact on right ventricular (RV) function. It has variable aetiologies and complex clinical manifestations [1].

Presently the gold standard method for diagnosis of PH is right heart catheterization [2,3] However it has limitations in terms of availability, feasibility, procedure related complications and cost. 2D Echocardiography is thus popularized by overcoming these limitations, with a certain amount of inaccuracy related to mathematical assumptions made during calculating right heart pressures.

As RV bears the major brunt of PH; and assessment of RV dysfunction with available clinical and investigative parameters being relatively complex; we have tried to study RV function further in association with severity of PH with the help of 2D Echocardiography and tissue Doppler technique as the primary objective.

Materials And Methods: Study population: We recruited 60 patients admitted at our centre with more than 12 years of age and PH defined by RV systolic pressure (RVSP) of >=40 mm Hg between January 2011 to July 2012. Written informed consent was taken from all patients. Permission of local Ethics Committee for retrospective analysis of data was taken. In all patients, a detailed history was taken and clinical examination was done meticulously.

Echocardiography: Echocardiography was used as a screening tool for diagnosing PH as well as to estimate RV function. All patients were evaluated on 2D echocardiography with Doppler imaging including tissue Doppler. In M-Mode, measurements of RV end diastolic dimension (RVEDD) were taken. In 2D-Mode, right atrial (RA), pulmonary arterial (PA) and left atrial (LA) dimensions were taken. RV ejection fraction (RVEF) was calculated by volumetric assessment by method of disc. Values less than 35% were considered as abnormal RV function [4].

Doppler Echocardiography was used to estimate RVSP. The maximum tricuspid regurgitant jet velocity was recorded and RVSP was then calculated by Bernoulli's formula as follows; with values of RVSP between 40-55 mm Hg were considered as mild, 55-64 mm Hg as moderate and >=65 mm Hg as severe PH [5,6].

RVSP = (4 x tricuspid jet velocity squared) + RA pressure

Lastly tissue Doppler imaging was performed to measure tricuspid annular systolic excursion (TASE). Values less than 0.100 m/s were considered as abnormal RV function[4].

Statistical analysis: Data was analyzed using SPSS Software. Correlation coefficients (r) were calculated for the relationship between RVSP, a measure of PH severity; and RVEF and TASE, the measures of RV dysfunction. Correlation coefficients for the relationship between RVEF and TASE were also calculated.

Results: The mean age of the study population was 50.2 years (range 14- 77 years) with male: female ratio being 1.3:1.

Echocardiographic mean population parameters are depicted in Table 1.

Table 1: Analysis of mean population parameters on 2D echocardiography.

2D Echocardiogrphic Parameter	Mean Value
RVEDD (mm)	27.82
RA Dimension 1 (mm)	48.38
RA Dimension 2 (mm)	40.78
PA Dimension (mm)	24.10
LA Dimension (mm)	37.20
RVEDV (mm^3)	52.32
RVESV (mm^3)	30.73
RVEF (%)	41.35
RV Systolic Pressure (mm Hg)	58.02
LVEF (%)	51.00
Mitral E/e'	15.32
TASE (Sm in m/s)	0.1063
TASE (e' in m/s)	0.1044
TASE (a' in m/s)	0.0889

Mean RVSP was 58.02% suggestive of moderate PH; while mean RVEF was 41.35% and mean TASE was 0.1063 m/s which were not suggestive of significant RV dysfunction. Most (51.7%) of the patients had mild PH; followed by severe PH (28.3%) and moderate PH (20%) as shown in figure 1. There was significant (p<0.0001) moderate negative correlation between RVSP and RVEF with r=-0.5670 i.e. with increasing RVSP, there was proportionate decrease in RVEF as shown in figure 2.

Figure 1: Analysis of severity of PH based upon RVSP

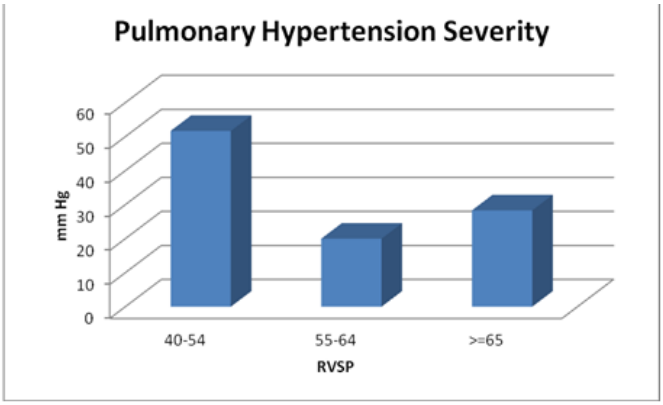
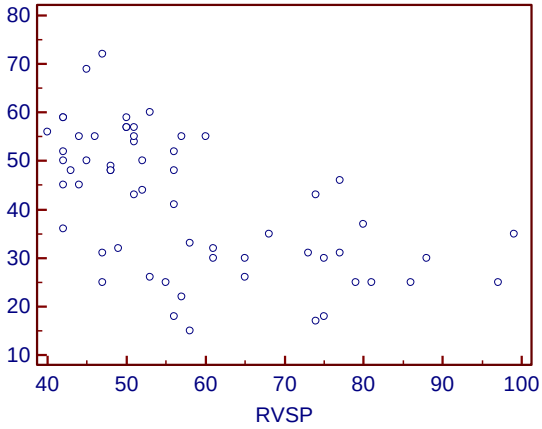


Figure 2: Analysis of correlation between 2D Echocardiographic RVSP and RVEF



RVEF of <35% was considered significantly abnormal [4]. Further derivation of Receiver Operating Characteristic (ROC) curve showed area under curve (AUC) of 0.816 which suggested significant accuracy of the data with values of RVSP more than 54 mm Hg being able to detect RV dysfunction (based on RVEF <35%) with 83% sensitivity and 73% specificity.

There was significant (p<0.001) mild negative correlation between RVSP and TASE with r=-0.4166 i.e. with increasing RVSP, there was proportionate decrease in TASE as shown in figure 3. TASE <0.100 m/s was considered significantly abnormal [4]. Derivation of ROC curve here showed AUC of 0.775, which again suggested significant accuracy of the data with values of RVSP more than 52 mm Hg having ability to detect RV dysfunction (based on TASE <0.100 m/s) with 79% sensitivity and 72% specificity.

Finally, there was significant (p<0.0001) moderate positive correlation found between RVEF and TASE with r=0.5821 i.e. with decreasing

RVEF, there was proportionate decrease in TASE as depicted in figure 4.

Figure 3: Analysis of correlation between 2D Echocardiographic RVSP and doppler TASE

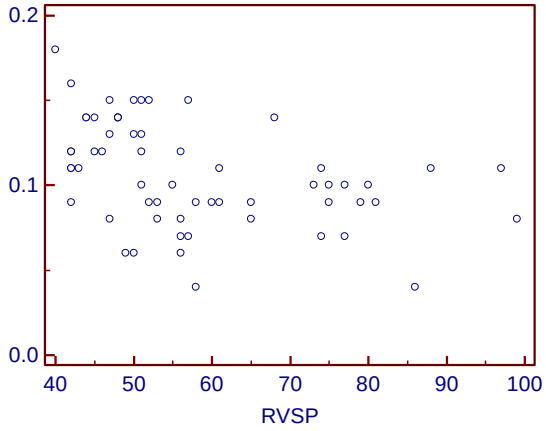
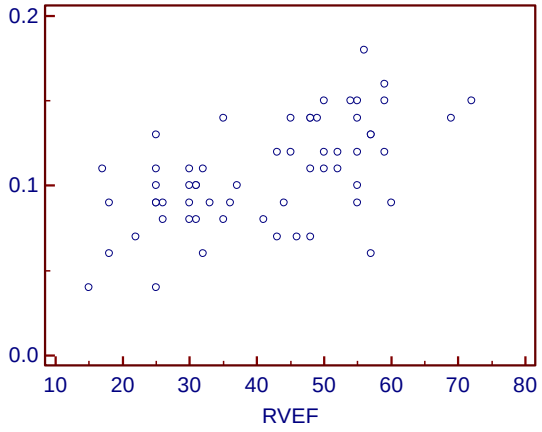


Figure 4: Analysis of correlation between 2D Echocardiographic RVEF and doppler TASE



Discussion: APH is a rare disorder involving pulmonary vasculature with subsequent adverse effects on RV function. The symptoms are often difficult to dissociate from those caused by a known underlying pulmonary or cardiac disorder. 2D Echocardiography presently is a widely available, easy, non invasive and cost effective tool to assess the severity of PH; however RV function assessment using it is not as popular.

With advances in transducer technology and imaging software, ability of detecting smaller eccentric tricuspid regurgitation jets with higher ease has made 2D echocardiography an important screening tool in noninvasive assessment of PH. RVSP is a reasonably accurate and easily available means for grading the severity of PH.

2D echocardiographic evaluation of RV volumes and thus RVEF is inherently limited by non-geometric RV shape and absence of validated formulae. Also RV/PA pressures estimated by Doppler do not have adequately proven correlation with their invasive gold standard. However this conventional limitation of underestimation of RVSP by 2D Echocardiography can be overcome by more dedicated approach using high resolution equipment. In a study by Fisher et al, findings suggested that Doppler echocardiography was inaccurate (defined as being greater than +/-10 mm Hg of the invasive measurement) in 48% of cases. Overestimation and underestimation of pulmonary artery systolic pressure by Doppler echocardiography occurred with a similar frequency (16 vs. 15 instances, respectively). The magnitude of pressure underestimation was greater than overestimation (-30 +/- 16 vs. +19 +/- 11 mm Hg; P = 0.03)[7]. However, in another study by Robyn J Barst et al reported a high correlation (0.57 to 0.93) between TTE (transthoracic echocardiography) and RHC (right heart catheterization) measurements of PASP. Reported sensitivity of TTE-estimated PASP for detecting PAH ranged from 0.79 to 1.00 and specificity from 0.60 to 0.98 [8].

The methodology in our study involved the use of noninvasive techniques including 2D echocardiography, Doppler study and tissue Doppler imaging; all of which have subjectivity and operator dependency. However attempts to decrease this fallacy are made by using newer techniques including Real-time 3-Dimensional Echocardiography (RT3DE). In the study by Morikawa T et al, all inter- and intraobserver variability values for the RV end-diastolic volume, RV end-systolic volume, and RVEF were <17% [9]. They suggested that RT3DE with a 2-dimensional summation method might provide comparable and feasible measurements of the RV volume in patients with PH compared to MRI [9].

We chose values of RVSP between 40-55 mm Hg, 55-64 mm Hg and >=65 mm Hg as mild, moderate and severe PH.[6] However it will be worth mentioning that there are no strict definitions of mild, moderate, or severe PH. These characteristics are Guidelines only.

Our analysis suggested significant negative correlation between RVSP and RVEF. Morikawa T et al in their study also suggested that RVEF significantly decreased with PH. A significant negative correlation was found between RVSP and RVEF in the study [9]. A study by D Chemla et

al also showed that RVEF is an independent prognostic factor in patients with PH complicating chronic heart failure. In patients with advanced heart failure, RVEF ≥35% at rest and during exercise is a more powerful predictor of survival than $\dot{V}_{O2.}$(Peak Oxygen Uptake)[10] . In our study, we used disc summation technique to calculate RVEF. RT3DE measured RVEF that is considered most accurate, correlates better with RVEF by disc summation as compared to visual/ RVFAC(RV fractional area change) methods as shown in a study by Sarah Chua et al [11].

Our analysis also showed significant negative correlation between RVSP and TASE. Anthony S. McLean and colleagues also showed that TASE, correlated well with RVSP. They showed that RVD/T_{peak} ratio offered the best correlation and, at a cutoff of 0.22m/s, predicted the presence of pulmonary hypertension with 80% sensitivity and 83% specificity [12]. Meluzin and colleagues subsequently examined the prognostic importance of pulsed tissue Doppler, finding the TASE value of < 0.108 m/s as an independent predictor of event-free survival and overall survival in symptomatic heart failure patients [13].
We also found significant positive correlation between 2D Echocardiographic RVEF and tissue Doppler TASE. In the study be Kaul S et al, excellent correlation was found with TASE as assessed by 2D echocardiography and RVEF assessed by radioangiography [14].In another study by Wang Jing et al, significant positive correlation was found between RT3DE assessment of TASE and RVEF (r=0.90)[15] . Jian wen Wang et al, compared MRI measurements of RVEF with echocardiographic TASE and showed a significant correlation. Furthermore, cut off value of <0.088m/s for TASE had a sensitivity and specificity of 80% and 79% respectively for predicting RVEF <45%[16] . In the study by G.B. Bleeker et al, TASE of < 0.115m/s identified right ventricular dysfunction with a sensitivity of 90% and specificity of 85%[17].

For the conclusions that are drawn, the study population is limited to 60 patients and has subsequently limited strength of its subgroups which remains the limitation of our study. However the results emphasize the clinical implications of 2D Echocardiographic measurements of RVSP and TASE by Tissue Doppler imaging for PH assessment in routine practice.

Conclusion: RVEF and TASE are the markers with significant value in identifying RV dysfunction and in prognosticating a patient with PH and can be measured by easy, noninvasive and cost effective tool like 2D Echocardiography and Tissue Doppler Imaging.

Acknowledgements: Wers acknowledge guidance and support given by Dr. K. K. Trivedi, Cardiologist at Vadodara.

References:

1. Simonneau G, Robbins IM, Beghetti M, et al. Updated clinical classification of pulmonary hypertension. J Am Coll Cardiol. 2009 Jun 30. 54(1 Suppl):S43-54.
2. Hoeper MM, Bogaard HJ, Condliffe R, et al. Definitions and diagnosis of pulmonary hypertension. J Am Coll Cardiol 2013; 62:Suppl., D42-D50.
3. Galie N, Humbert M, Vachiery JL, et al. 2015 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. Eur Respir J 2015; 46:903-975.
4. Ling LF, Marwick TH. Echocardiographic Assessment of Right Ventricular Function How to Account for Tricuspid Regurgitation and Pulmonary Hypertension, J Am Coll Cardiol Img. 2012;5(7):747-753.
5. Come PC. Echocardiographic recognition of pulmonary arterial disease and determination of its cause. Am J Med 1988;84:384-393.
6. Fisher MR, Accuracy of Doppler echocardiography in the hemodynamic assessment of pulmonary hypertension. Am J Respir Crit Care Med. 2009 Apr 1;179(7):615-21.
7. Fisher MR. Accuracy of Doppler echocardiography in the hemodynamic assessment of pulmonary hypertension. Am J Respir Crit Care Med. 2009 Apr 1;179(7):615-21.
8. Barst RJ, McGoon M, Torbicki A, Sitbon O, Krowka MJ, Olschewski H, et al. Diagnosis and differential assessment of pulmonary arterial hypertension. J Am Coll Cardiol. 2004;43(12s1):S40-S47.
9. Morikawa T, Murata M, Okuda S, Tsuruta H, Iwanaga S, Murata M, et al. Quantitative analysis of right ventricular function in patients with pulmonary hypertension using three-dimensional echocardiography and a two-dimensional summation method

compared to magnetic resonance imaging. Am J Cardiol. 2011 Feb 1;107(3):484-9.
10. Chemla D, Castelain V, Herve P, Lecarpentier Y, Brimioulle S. Haemodynamic evaluation of pulmonary hypertension. *Eur Respir J* 2002 Nov; 20(5): 1037–1049.
11. Chua S, Levine RA, Yosefy C, Handschumacher MD, Chu J, Qureshi A, et al. Assessment of right ventricular function by real-time three-dimensional echocardiography improves accuracy and decreases interobserver variability compared with conventional two-dimensional views. Eur J Echocardiogr. 2009 July; 10(5): 619–624.
12. McLean AS, Ting I, Huang SJ, Weasley S. The use of the right ventricular diameter and tricuspid annular tissue Doppler velocity parameter to predict the presence of pulmonary hypertension. Euro J Echocardiogr. 2007 Mar; 8(2):128-36.
13. Meluzin J, Spinarova L, Dusek L, Toman J, Hude P, Krejci J. Prognostic importance of the right ventricular function assessed by Doppler tissue imaging. Eur J Echocardiogr 2003; 4: 262-71.
14. Kaul S, Tei C, Hopkins JM, Shah PM. Assessment of right ventricular function by 2D echocardiography. Am Heart J. 1984. Mar;107(3):526-31.
15. Jing W, Xinfang W, Mingxing X, Ya Y, Quing LV, Ying Y, et al. Evaluation of right ventricular volume and systolic function by real-time 3D echocardiography. J Hauzhong Uni Sci Technolog. 2005, Feb; 125(1):94-96.
16. Wang J, Prakasa K, Bomma C, Tandri H, Dalal D, James C, et al. Comparison of novel echocardiographic parameters of right ventricular function and ejection fraction by cardiac MRI. J Am Soc Echocardiogr. 2007, Sept; 20(9):1058-1064.
17. Bleeker GB, Steendijk P, Holman ER, Yu C-M, Breithardt OA, Kaandorp TAM, et al. Assessing right ventricular function, role of echocardiography and complementary techniques. Heart. 2006. April; 92(suppl);19-126.

Conflict of interest: None

Funding: None

Cite this Article as: Thanky A, Gandhi A, Trivedi S. Non Invasive Measurement Of Right Ventricular Function In Pulmonary Hypertension: Study From A Tertiary Care Centre In Gujarat. Natl J Integr Res Med 2018; 9(6):8-12