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RESEARCH ARTICLE

A COMPARATIVE STUDY BETWEEN VARIOUS ECHOCARDIOGRAPHIC METHODS OF SCREENING FOR PULMONARY HYPERTENSION IN HEART FAILURE

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ABSTRACT

Pulmonary hypertension (PH) is defined as mean pulmonary artery pressure (MPAP) ≥25mmHg. Right heart catheterization (RHC) is the gold standard for PH assessment but it has fallen out of fashion for the routine assessment of PH due to its invasiveness. More recently, Doppler echocardiography which is a non-invasive, cost-effective, and more readily available tool has become a favorable modality for the screening and serial assessment of PH in HF. The aim of this study was to identify Echocardiographic doppler correlates of pulmonary hypertension in heart failure patients. This study was carried out at the University of Benin Teaching Hospital (UBTH), Benin City, Edo state, Nigeria. The study population included one hundred and fifty patients (150) who were consecutively admitted into the medical wards for heart failure. This was a descriptive cross-sectional study where consenting patients who met the inclusion criteria were recruited consecutively. PASP, MPAP, PAAT,PADP, RVET and PAAT/RVET measurement were obtained, MPAP was derived from PASP using the Chemla formula. PH was defined as MPAP >25mmHg. Pulmonary artery acceleration time was measurable in all the subjects in the study population (100%), while TR was measurable in 104 (69.3%) of them. The prevalence of PH in HF using MPAP (PAAT) was 54%, while using PASP it was 44%. Tricuspid regurgitation was measurable in 104 (69.3%) subjects in the study population. The prevalence of pulmonary hypertension using PASP was 54%. This showed that patients with tricuspid regurgitation had significantly higher mean pulmonary artery pressure ($p<0.001$). Patients with PH had higher mean pulmonary artery systolic pressure of 47.4±1.5mmHg, while those without PH had mean pulmonary artery systolic pressure of 31.3±7.1mmHg ($p = 0.017$). Similarly, patients with pulmonary hypertension had higher mean pulmonary artery pressure of 32.7±6.4mmHg compared to patients without pulmonary hypertension ($p < 0.001$). The mean pulmonary artery pressure derived from pulmonary artery acceleration time (PAAT) was significantly higher in patients with PH. Patients with PH had mean pulmonary artery pressure of 38.4±3.1mmHg while those without PH had a mean value of 15.8±0.6 ($p<0.001$). A significant positive correlation was found between MPAP derived from PAAT and PASP in patients with PH, without PH and the total population ($r=0.74$, $p=<0.001$, $r= 0.85$, $p<0.001$, $r= 0.90$, $p<0.001$). There was a significant inverse relationship between PAAT/RVET and RVSP ($p<0.001$). Also, Linear regression analysis showed significant prediction of PASP from PAAT [$R^2 = 0.641$; $F = 50.09$ ($p<0.001$); $B=1.34$; $\beta = 0.80$; $p<0.001$]. ***Conclusion:*** Pulmonary hypertension is a common finding in patients admitted for heart failure. PAAT and PAAT/RVET have been shown to be excellent correlates of RVSP therefore utilizing them for technically difficult Echo procedures where good TR spectral Doppler flow cannot be gotten will be an invaluable tool.

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INTRODUCTION

Pulmonary hypertension (PH) is defined as mean pulmonary artery pressure (MPAP) ≥25mmHg. The gold standard for diagnosing PH is right heart catheterization (RHC)[1]. However it is an invasive procedure with associated risks. [2]This makes it unsuitable for routine evaluation of PH in heart failure (HF). Studies have demonstrated an adequate correlation between RHC and Doppler echocardiography for the diagnosis of PH. Following the Evaluation Study of Congestive Heart Failure and Pulmonary Artery Catheterization Effectiveness (ESCAPE) trial, Doppler echocardiography is now more commonly used to diagnose PH in HF. [3] It is non-invasive, cost-effective, and more readily available alternative for screening and serial assessment of PH in HF. Several methods have been used for assessment of PH in cardiac disease using Doppler echocardiography. Most local and international studies used pulmonary artery systolic pressure (PASP)

derived from tricuspid regurgitation (TR). TR is measurable in only less than 75% of cases, hence possible PH in people without TR may have been ignored in these studies. [4,5]. Many reports of pulmonary artery pressure measurements were done using Tricuspid regurgitant jet velocity to estimate the right ventricular systolic pressure (RVSP).[5–9] These have been in-patients who have tricuspid regurgitation and no pulmonary stenosis. However, some patients do not have tricuspid regurgitation and so estimating pulmonary artery pressure using RVSP may not be possible. Pulmonary artery acceleration time (PAAT) has been described as useful in estimating MPAP (mean pulmonary artery pressure) in patients without TR. PAAT is measurable in 99% of cases. [8] Other suggestions of using the PAAT/Right Ventricular Ejection Time (RVET) ratio <0.3 to diagnose PH have been reported (REF). The aim of this study is to find out how these Echocardiographic methods of estimating PH correlate with each other. We also seek to ascertain if a relationship exists between these ECHO variables and increasing levels of levels of pulmonary artery pressure. (Key words: Pulmonary hypertension, Pulmonary artery acceleration time, Pulmonary artery systolic pressure).

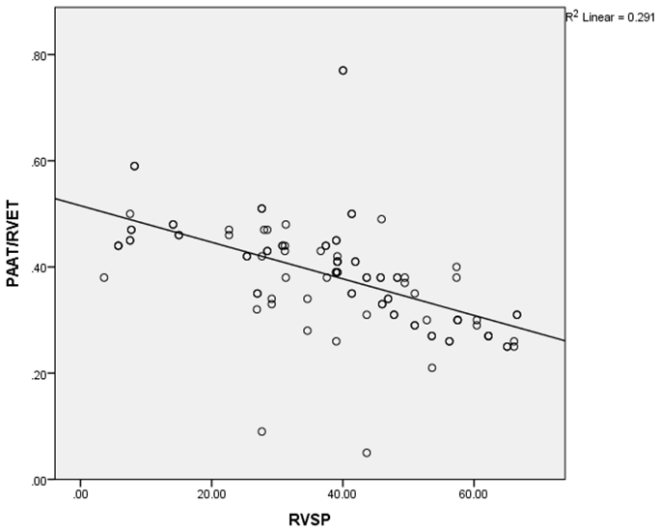
METHODS

This study was carried out at the University of Benin Teaching Hospital (UBTH), Benin City, Edo state, Nigeria. The study population included one hundred and fifty patients (150) who were consecutively admitted into the medical wards for heart failure. This was a descriptive cross-sectional study where consenting patients who met the inclusion criteria were recruited consecutively. The inclusion criteria were subjects ≥ eighteen years and subjects with signs and symptoms of HF as validated by the Framingham's criteria. [10] Those aged less than eighteen years, non-consenting patients, a diagnosis of chronic obstructive airway disease and with pulmonary valve stenosis were excluded from this study. Ethical approval was obtained from the University of Benin Teaching Hospital Ethical Committee. Informed consent was also obtained from each subject after full explanation of the study protocol. A structured questionnaire was used to collect information on socio-demographic characteristics. The diagnosis of heart failure was made using the Framingham Criteria. [10] Doppler echocardiography was performed using an ALOKA PHD PROSOUND SSD 4000SV with a 3.5-5MHZ transducer. Standard two-dimensional, M-mode and Doppler images were obtained. Patients were examined in the left lateral recumbent position using standard parasternal and apical views. Complete 2D Echo examination was performed according to the recommendation of the American Society of Echocardiography (ASE). [11] PASP measurement was carried out as follows: In the absence of pulmonary stenosis, PASP equals right ventricular systolic pressure (RVSP). This was estimated by adding the systolic pressure gradient and the right atrial pressure. The systolic pressure gradient was measured from the tricuspid regurgitant jet by placing the Doppler beam between the two tips of the tricuspid valve leaflets. [9,12]Thereafter, MPAP was derived from PASP using the Chemla formula: MPAP = PASP X 0.61 + 2 [13]. PH was defined as MPAP >25mmHg. MPAP of 25 - 34mmHg, 35 – 44mmHg and >45mmHg was classified as mild, moderate and severe respectively.[14] Normal <35mmHg, Mild 36-44mmHg, Moderate 45-59mmHg, Severe ≥60mmHg.

PAAT measurement was carried out as follows: the pulmonary artery acceleration time was measured both for those with and without significant TR. This was obtained from the parasternal short axis view by placing the pulse wave Doppler on the pulmonary artery. MPAP was estimated using the following formula: MPAP = 79 – 0.45(PAAT). The right ventricular ejection time was also. Continuous wave Doppler was used to measure the end pulmonary regurgitant velocity. Pulmonary artery diastolic pressure (PADP) was calculated using the following equation: 4(PR-end velocity) ^{2} +RAP. Data obtained was entered into and analyzed using the International Business Machines Statistical Product and Service Solutions (IBM-SPSS) version 23.0. Categorical data were expressed as frequencies and percentages while continuous data were presented as means (standard deviation). Frequencies were compared using the Pearson's Chi-Square test. Continuous data was compared between two groups using the independent t-test while correlation was done using the Pearson correlation with multiple logistic regressions done for significant correlates where applicable. A p-value ≤ 0.05 was considered significant for all statistical comparisons.

RESULTS

Pulmonary artery acceleration time was measurable in all the subjects in the study population (100%), while TR was measurable in 104 (69.3%) of them. The prevalence of PH in HF using MPAP (PAAT) was 54%, while using PASP it was 44%. Tricuspid regurgitation was measureable in 104 (69.3%) subjects in the study population. The prevalence of pulmonary hypertension using PASP was 54%. The mean tricuspid regurgitant velocity was 3.0±0.5m/s in patients with PH, while it was 1.9±0.7m/s in patients without PH. This showed that patients with tricuspid regurgitation had significantly higher mean pulmonary artery pressure (p<0.001).



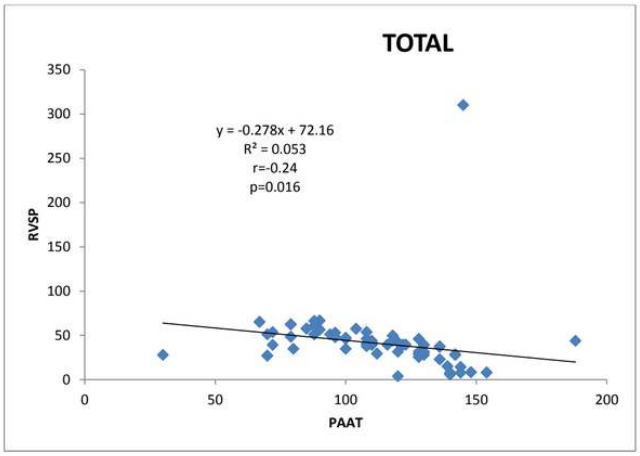
Key: MPAP-Mean pulmonary artery pressure, PASP-Pulmonary artery systolic pressure, PAAT-Pulmonary artery acceleration time, PH-Pulmonary hypertension

Figure 1. Correlation Between Mpap (Pasp) And Mpap (Paat)

Table 1. Right Venricular Doppler Echocardiographic Parameters In The Study Population

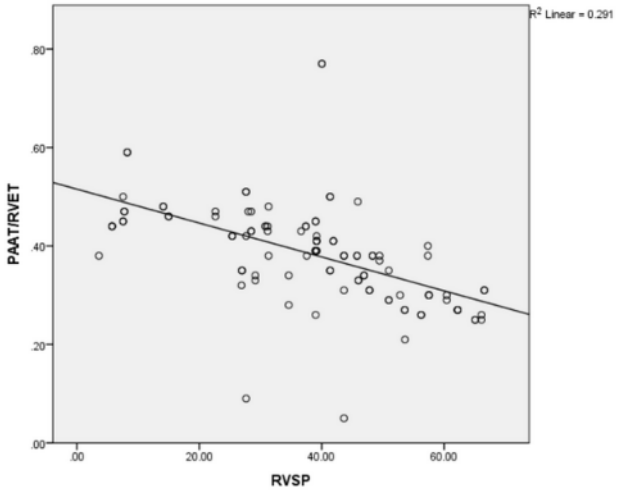
	PH PRESENT n=81 Mean (SD)	PH ABSENT n=69 Mean (SD)	t	P
TRVmax	3.03 (0.51)	1.93 (0.72)	-10.91	<0.001**
RVET	266.71 (90.16)	295.01 (31.56)	2.46	0.015**
PAAT	98.62 (19.56)	137.78 (16.56)	13.07	<0.001**
PADP	17.15 (6.49)	12.26 (5.70)	-3.90	<0.001**

Patients with PH had higher mean pulmonary artery systolic pressure of 47.4±1.5mmHg, while those without PH had mean pulmonary artery systolic pressure of 31.3±7.1mmHg (p = 0.017). Similarly, patients with pulmonary hypertension had higher mean pulmonary artery pressure of 32.7±6.4mmHg compared to patients without pulmonary hypertension (p < 0.001). Pulmonary artery acceleration time was measurable in all the subjects. The prevalence of PH was 54% using PAAT. The mean PAAT was shorter in patients with PH. The mean PAAT was 98.6±19.6millisec and 137.8±16.6millisecs for subjects with and without PH respectively (p<0.001). The mean pulmonary artery pressure derived from pulmonary artery acceleration time (PAAT) was significantly higher in patients with PH. Patients with PH had mean pulmonary artery pressure of 38.4±3.1mmHg while those without PH had a mean value of 15.8±0.6 (p<0.001).



Key: MPAP-Mean pulmonary artery pressure, PASP-Pulmonary artery systolic pressure, PAAT-Pulmonary artery acceleration time, PH-Pulmonary hypertension

Fig. 2. Correlation Between Rvsp And Paat



Key: MPAP-Mean pulmonary artery pressure, PASP-Pulmonary artery systolic pressure, PAAT-Pulmonary artery acceleration time, PH-Pulmonary hypertension

Figure 3. Correlation between paat/rvet and rvsp

A significant positive correlation was found between MPAP derived from PAAT and PASP in patients with PH, without PH and the total population (r=0.74, p=<0.001, r= 0.85, p<0.001, r= 0.90, p<0.001). [Table II] Also, Linear regression analysis showed significant prediction of PASP from PAAT [R^2 = 0.641; F = 50.09 (p<0.001); B=1.34; β = 0.80; p<0.001].

DISCUSSION

Pulmonary hypertension (PH) occurs commonly among patients with heart failure (HF). [15] It is one of the factors that determine the severity and outcome in patients with heart failure. This study findings show a slight female preponderance of PH in HF. This is similar to the finding of Karaye et al in Northern Nigeria where females accounted for 49 (61.25%) of cases of HF and PH was found in 30 (61.22%) of them. [16] In addition, another Japanese study demonstrated that women are more prone to having reactive PH. [17] Women tend to have a higher preponderance of PH due to the presence of high levels of oestrogen while testosterone has been speculated to have a possible protective effect. [18] Although noted to be more common in women, pulmonary hypertension is also known to have a better prognosis in women than in men. [19,20,] In this study, a strongly positive correlation between MPAP derived from PAAT and PASP was found both for patients with and without PH a finding similar to earlier research by Kibar et al [8] also there was a significant inverse relationship between PAAT/RVET and RVSP (p<0.001) as shown in figure 3. Similarly, Nagel et al showed that there was a positive correlation between MPAP and PASP [21]. Although the MPAP derived from PAAT was slightly higher than that derived from PASP in this study, both methods were able to significantly detect the presence or absence of PH. It is imperative to note that most studies on PH in heart failure were estimated Echocardiographically using the pulmonary artery systolic pressure. They excluded patients who did not have tricuspid regurgitation, thereby ignoring possible pulmonary hypertension in them [22] a lacuna which this study finds an answer to. Furthermore, there is existing evidence suggesting that factors such as body habitus and parenchymal lung disease may also limit the assessment of the TR jet velocity thus making it impossible to determine the presence of pulmonary hypertension from PASP in as much as 60% of patients using echocardiography. [23] Consequently, this study demonstrates an alternate option for clinicians who would need to assess the presence of pulmonary hypertension in the category of patients who have limitations with the use of PASP. Thus, the use of PAAT and its correlate (PAAT/RVET) in assessing PH will be an invaluable tool as an adjunct to estimating PH using echocardiography especially in patients without tricuspid regurgitation where right heart catheterization remains a luxury.

CONCLUSION

Pulmonary hypertension is a common finding in patients admitted for heart failure. PAAT and PAAT/RVET have been shown to be excellent correlates of RVSP therefore utilizing them for technically difficult Echo procedures where good TR spectral Doppler flow cannot be gotten will be an invaluable tool.

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