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Correlation of Doppler echocardiography with cardiac catheterization in estimating pulmonary capillary wedge pressure: A tertiary level hospital finding in Bangladesh

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Abstract
This prospective cross sectional study was conducted in the department of cardiology in National Institute of Cardiovascular Diseases (NICVD), Dhaka during the period of January 2002 to December 2002. A total of 50 patients with coronary artery disease subjected to diagnostic cardiac catheterization for evaluation of CAD were studied and the patients were grouped into two groups, group I having PCWP ≥12-<18 mmHg and group II having PCWP ≥18 mmHg. The aims of the study were to correlate the Pulmonary Capillary Wedge Pressure (PCWP) estimated by Doppler echocardiography with that obtained at cardiac catheterization. Among 2D and M mode echocardiographic indices it was observed that ejection fraction was significantly lower and maximal left atrial volume (MLAV) was significantly higher among patients having PCWP ≥18 mmHg ($p<0.05$). Among Doppler derived mitral flow variables deceleration rate was significantly higher ($p<0.05$) among patients having PCWP ≥18 mmHg. No statistically significant difference was found between two groups in terms of pulmonary venous flow variables. A statistically significant negative correlation of deceleration time ($r=-0.483$; $p=0.001$) and ejection fraction ($r=-0.334$; $p=0.01$) and a statistically significant positive correlation of peak E wave ($r=0.345$; $p=0.01$) and deceleration rate ($r=0.651$; $p=0.001$) was found with catheter derived PCWP. The correlation coefficient between measured and estimated PCWP (from equation 1) was ($r=0.678$) which was highest. When pulmonary venous flow variables were included with mitral flow variables into multiple linear regression analysis, the resulting correlation coefficients were ($r=0.670$) for equation 2 and ($r=0.652$) for equation 3. In all three equations deceleration rate was the most important determinant of PCWP. Therefore in patients with coronary artery disease pulmonary capillary wedge pressure can reliably be estimated by combining Doppler echocardiographic variables of mitral flow and pulmonary venous flow and that mitral flow velocity indexes contribute most significantly to such estimation. Among the mitral flow variables, deceleration rate is the most important determinant of PCWP.

Key words
Pulmonary Capillary Wedge Pressure, Cardiac Catheterization, Doppler echocardiography, Bangladesh.

Introduction

Pulmonary Capillary Wedge Pressure (PCWP) is an established index of cardiac function and an essential component in the management of patients with congestive heart failure and in critically ill patients. It provides the haemodynamic status in patients with acute myocardial infarction. Several Doppler echocardiographic assessments of haemodynamic variables in patients with advanced heart failure are accurate and reproducible. This noninvasive methodology may assist with monitoring and optimizing medical therapy in such patients. At present echocardiography is the most useful and widespread tool used in heart failure patients with regard to diagnosis, assessment and haemodynamic characterization[1-3].

Mitral Doppler echocardiography provides a simple and noninvasive method of estimating and monitoring PCWP in patients with severe left ventricular systolic dysfunction[3]. Although all mitral Doppler variables were independent predictor of PCWP, among mitral flow velocity indexes deceleration rate showed strongest correlation with PCWP followed by E/A ratio and deceleration time[4].

Several studies using both transoesophageal and transthoracic Doppler echocardiography have found close correlation between pulmonary venous flow variables and left ventricular filling pressures, suggesting that these variables may be more accurate predictorof filling pressure than are mitral flow variables[5-7].Within pulmonary venous flow indices systolic fraction of peak velocities showed strongest inverse correlation with PCWP.[4] Earlier studies have shown that Doppler indices based on transmitral and pulmonary venous flow provide an accurate means of estimating PCWP [7-10] better with peak early diastolic filling velocity/flow propagation velocity (E/FPV) by color M-mode Doppler than with other Doppler indices.[11,12] Color M-mode Doppler LV inflow propagation velocity (LVIPVcmm) has been proven to be related to the time constant of isovolumic LV relaxation (tau).[13-15]

In an attempt to refine these techniques more recent studies have analyzed pulmonary venous flow velocity in conjunction with mitral flow velocity.

In patients with DCM and heart failure PAWP can reliably estimated by combining Doppler-echocardiographic variables of mitral and pulmonary venous flow. Deceleration rate of early diastolic mitral flow and systolic fraction of pulmonary venous flow were the most relevant determinants of PCWP whereas smaller contribution was made by difference in duration of pulmonary venous reverse flow and mitral flow at atrial contraction.[4]

In patients with congestive heart failure due to DCM who are in atrial fibrillation a relatively accurate estimation of PAWP can be obtained by Doppler index of mitral and pulmonary venous flow. Deceleration rate of early diastolic mitral flow, left ventricular isovolumic relaxation time and systolic fraction of pulmonary venous flow were independent predictors of PAWP.[16]

In our present study, we aimed at correlating a noninvasive estimate of PCW with that obtained at cardiac catheterization.

Materials and methods

Study Patients

We prospectively studied 50 consecutive patients with coronary artery disease that were admitted at the Department of Cardiology, National Institute of Cardiovascular Diseases, Dhaka and underwent catheterization for coronary artery disease between January 2002 to December 2002. We included patients with myocardial infarction. Exclusion criteria included inadequate doppler recording, mitral stenosis, severe mitral regurgitation and AV block. The total population was divided according to catheter derived PCWP.[4] Since there was no patient having PCWP < 12 mmHg, patients were divided into two groups. All patients were evaluated by history and clinical examination with special emphasis on risk factors e.g. DM. hypertension, smoking, dyslipidaemia, family history of IHD, NYHA class I-IV, CCS class I-IV, Killip class I-IV, pulse and blood pressure. The Ethics Committee of National Institute of Cardiovascular Diseases, Dhaka approved the study protocol. The principal investigator obtained informed written consent from all patients before cardiac catheterization.

M-mode and 2D – echocardiography

M-mode and 2D - echocardiography examination was performed using the baseline shift technique proposed by Takatsuji et. al.[14] since it is sometimes difficult to determine its boundary by the wave front method. This examination was done to assess chamber enlargement and ventricular systolic function. Careful attention was paid to valvular and congenital pathology. Maximal left atrial volume was determined by area length method from 2D apical 2 and 4 chamber view.

Doppler echocardiography

Each valve was evaluated by pulsed wave and continuous wave Doppler echocardiography followed by color mapping. Same technique was also applied to determine congenital shunt abnormality. 2D guided apical 4-chamber view was used to assess transmitral flow and pulmonary venous flow parameters. Measurements were made from an average 3 to 5 consecutive velocity curve detected by pulsed wave Doppler. Pulsed Doppler sample volume were placed adjacent to the tips of mitral valve leaflets in diastole and into the right upper pulmonary vein in 1-2 cm depth to see the transmitral flow and pulmonary venous flow velocity parameters respectively.

Following transmitral flow parameters were measured :

- i) Maximal early diastolic velocity -E wave m/s
- ii) Maximal late diastolic velocity –A wave m/s
- iii) E/A ratio.
- iv) Deceleration time of early diastolic velocity -DTsec.
- v) Deceleration rate-DR m/sec^2-(E/DT)
- vi) Duration of late diastolic velocity wave-dA sec

Following pulmonary venous flow parameters were measured

- i) Peak velocity of systolic forward flow- S wave m/s.
- ii) Peak velocity of diastolic forward flow- D wave m/s.
- iii) Systolic fraction of peak velocities- SF = S/S+D.
- iv) Duration of reverse flow at atrial contraction- dz sec. dZ-dA was calculated.

Doppler data obtained were used to derive three equations for estimation of PCWP. Equation 1 with 2D derived MLAV and mitral flow variables and equation 2 and 3 with mitral and pulmonary venous flow variables.

Cardiac catheterization

Both right sided and left heart catheterization were done in all patients. Modified Seldinger method using right or left femoral vein was applied for right sided catheterization. PCWP was measured by 6F Cournand catheter using transducer at the level of mid-axillary line with patient in supine position**.** Catheter was advanced under fluoroscopic control to inferior vena cava, next to right atrium, right ventricle and pulmonary artery. Next the catheter was advanced to the wedge position. This was done simply by having the patient take a deep breath and holding it while the catheter was advanced until its tip went no further and did not pulsate with the heart. Having the patients cough at this time catheter tip was advanced into a true 'wedge' position. The pressure waveforms were monitored and if had the appearance of a true wedge pressure was noted. Blood was sampled from the catheter. The pressure was confirmed as a true wedge pressure only if blood that was completely (95% or more) saturated with oxygen, was aspirated gently from the catheter.[17] Left heart catheterization with CAG and LV-graphy were done through femoral arterial approach after right heart catheterization by the femoral protocol for catheterization, carried out in the catheterization laboratory of National Institute of Cardiovascular Diseases. Left ventricular end diastolic pressure (LVEDP) was recorded before injecting dye into LV (i.e. LV graphy).

Statistical Analysis

The numerical data obtained from this study were analysed and significance of differences were estimated by using statistical methods. Initially the data were entered in Epi-Info database and then exported into SPSS version 10 for Windows and analysed. Results are reported as frequencies, percentages, means and standard deviations (SD) as applicable. The significance of differences between two groups according to PCWP was evaluated by an unpaired Student's t-test, chi-square test and Fisher's test as applicable. Pearson correlation coefficient was used to measure the relationship between catheter derived PCWP and echocardiographic variables. Stepwise multiple linear regression analysis was used to estimate the relation between parameters obtained by Doppler ultrasound examination and PCWP. The graphical representations, correlation test and Pearson correlation coefficient were employed to establish the relationship catheter derived PCWP and estimated PCWP and also to identify the best predictor of measured PCWP. Differences were considered significant at a value of ($p < 0.05$).

Results

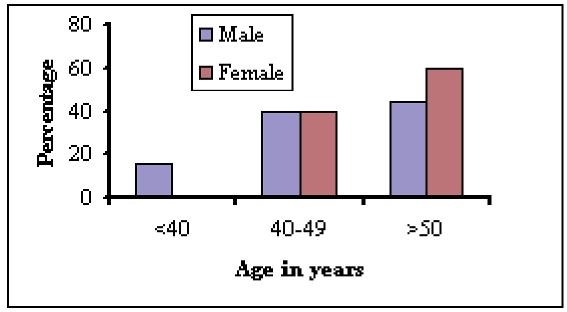
Doppler tracings of sufficient quality, for analysis were obtained in all patients. Table I and Fig-1 showed the age and sex distribution of the study patients.

Table I : Age and sex distribution of study patients

Age in years	Sex		Total (N=50)
	Male (n=45)	Female (n=5)	
<40	7 (15.6)	0 (0.0)	7 (14.0)
40-49	18(40.0)	2(40.0)	20(40.0)
>50	20(44.4)	3(60.0)	23(46.0)

N.B Figures in parenthesis indicate percentages

Figure. 1 Age and sex distribution of the study patients



Some summary results of the age and sex distribution are as follows:

- Mean±SD (Total): 47.0±8.9 years
- Male and Female ratio=9:1
- Age range=25-67 years.

In the study we examined 45 men (90%) and 5 women, with a mean age of 47.0 ± 8.9 years (mean ± SD), range 25 to 67 years. It was also observed that both male and female patient having more than one risk factors. For both group of patients smoking was found as the major risk factor. No significant differences were found in two groups of patients in terms of risk factors as well as PCWP (Table II)

Table II. Distribution of study subjects by risk factors and PCWP

Parameters	PCWP		Total (N=50)	p value
	≥12 - <18 mmHg (n=14)	≥18 mmHg (n=36)		
Mean age ±(SD) years	**47.8±8.6**	**46.7±9.0**	**47.0±8.9**	**0.708^{NS*}**
Sex				
Male	13(92.9)	32(88.9)	45(90.0)	0.675^{NS}
Female	1(7.1)	4(11.1)	5(10.0)	
Diabetes mellitus	4(28.6)	14(38.9)	18(36.0)	0.495^{NS}
Hypertension	6(42.9)	12(33.3)	18(36.0)	0.529^{NS}
Smoking	9(64.3)	24(66.7)	33(66.0)	0.873^{NS}
Dyslipidaemia	9(64.3)	22(61.1)	31(62.0)	0.836^{NS}
Family history of IHD	0(0.0)	2(5.6)	2(4.0)	0.368^{NS**}

* P value reached from unpaired student's t test
** P value reached from Fisher's exact test
P value reached from chi-square analysis
Figure in parenthesis indicate percentages
NS= Not significant (p>0.05)

It was observed that deceleration rate was significantly higher among the patients having PCWP > 18mmHg (Table III).

Table III. Mean distribution of Doppler Echocardiographic findings of mitral flow in relation to PCWP

Doppler echocardiography (Mitral flow)	Total (N=50) Mean±SD	PCWP ≥12 - <18 mmHg (n=14) Mean±SD	PCWP ≥18 mmHg (n=36) Mean±SD	p value
Peak-E wave (m/sec)	0.8±0.2	0.7±0.2	0.85±0.2	0.077^NS
Peak-A wave (m/sec)	0.7±0.2	0.65±0.2	0.73±0.1	0.144^NS
E/A ratio	1.2±0.4	1.18±0.45	1.20±0.4	0.895^NS
Deceleration time (DT) in sec	0.2±0.003	0.18±0.004	0.16±0.003	0.217^NS
Deceleration rate (DR-E/DT) m/sec^2	5.1±1.7	4.26±0.16	5.3±1.7	0.040^S
Duration of late diastolic velocity wave (dA) in sec	0.2±0.03	0.19±0.04	0.19±0.03	0.812^NS

p value reached from unpaired student's t test
NS= not significant (p>0.05)
S=significant (p<0.05)

No significant differences were found for mean distribution of Doppler Echocardiographic findings of pulmonary venous flow in relation to PCWP among two groups of patients (Tab IV).

Table IV. Mean distribution of Doppler echocardiographic findings of pulmonary venous flow in relation to PCW

Doppler echocardiography (Pulmonary venous flow)	Total (N=50) Mean±SD	PCWP ≥12 - <18 mmHg (n=14) Mean±SD	PCWP ≥18 mmHg (n=36) Mean±SD	p value
Peak S wave (m/sec)	0.44±0.2	0.51±0.2	0.42±0.21	0.175^NS
Peak D wave (m/sec)	0.39±0.1	0.41±0.09	0.38±0.16	0.523^NS
Systolic fraction of peak velocities (S/S+D)	0.53±0.08	0.54±0.06	0.52±0.08	0.055^NS
Duration of reverse flow at atrial contraction(dz) sec	0.17±0.02	0.17±0.02	0.17±0.02	0.754^NS

p value reached from unpaired student's t test NS= not significant (p>0.05)

A statistically significant negative correlation of deceleration time (r = -0.483) and ejection fraction (r = -0.334) and significant positive correlation of peak E wave (r = 0.345) and deceleration rate (r = 0.651) were observed with catheter derived PCWP (p<0.05). But no significant correlation was found between catheter derived PCWP and peak A wave, E/A ratio, duration of the late diastolic velocity wave (dA), peak S wave, peak D wave, systolic fraction of peak velocities, duration of reverse flow at atrial contraction (dz), dz-dA and MLAV (p> 0.05) (Table V)

Table V. Correlation between different echocardiographic variables and catheter derived PCWP

Echocardiographic variables vs. Catheter derived PCWP	Pearson Correlation co-efficient (r value) (N=50)	p value
Peak-E wave (m/sec)	0.345	0.014^S
Peak-A wave (m/sec)	0.224	0.117^NS
E/A ratio	0.066	0.648^NS
Deceleration time (DT) in sec	-0.483	0.001^S
Deceleration rate (DR-E/DT) m/sec^2	0.651	0.001^S
Duration of late diastolic velocity wave (dA) sec	-0.184	0.200^NS
Peak S wave (m/sec)	0.252	0.078^NS
Peak D wave (m/sec)	0.044	0.762^NS
Systolic fraction of peak velocities (S/S+D)	0.138	0.340^NS
Duration of reverse flow at atrial contraction (dz) in sec	-0.026	0.857^NS
dZ-dA in sec	0.183	0.204^NS
MLAV m^3	0.270	0.058^NS
Ejection fraction(%)	-0.334	0.018^S

P value reached from correlation test
S=significant (p<0.05) NS=not significant (p>0.05)

By combining mitral flow velocity and 2D echocardiographic variables in stepwise multiple linear regression analysis the first equation (Equation 1) for predicting PCWP derived. The most important determinant of PCWP was deceleration rate whereas peak early to late diastolic velocity ratio, deceleration time and maximal left atrial volume provided a smaller contribution. The correlation coefficient between measured and estimated PCWP from equation 1 was r=0.678. When pulmonary venous flow variables included with mitral flow variables into multiple linear regression analysis, the resulting correlation coefficient was r=0.670 (second equation). In equation 3 deceleration rate was the only significant predictor of PCWP and correlation coefficient was r=0.652. (Table VI)

Table VI. Stepwise multiple linear regression analysis: Correlation between Pulmonary Capillary Wedge Pressure measured and estimated

Stepwise multiple linear regression analysis	Pearson correlation coefficients (r value)
With 2DE and mitral flow variables in study subjects	
Deceleration rate	0.651
Deceleration rate + Peak early/late diastolic velocity ratio	0.664
Deceleration rate + Peak early/late diastolic velocity ratio+ Deceleration time	0.666
Deceleration rate + Peak early/late diastolic velocity ratio+ Deceleration time+ maximal left atrial volume	0.678
Equation *1 PCWP: 1.43XDR+1.32XE/A-0.024XDT+0.02XMLAV+9.2*	
With 2DE and mitral + Pulmonary venous flow variables in study subjects	
Deceleration rate	0.651
Deceleration rate + Systolic fraction of peak velocities	0.652
Deceleration rate + Systolic fraction of peak velocities + dZ-dA	0.659
Deceleration rate + Systolic fraction of peak velocities + dZ-dA + peak early/late diastolic velocity ratio	0.670
Equation *2 PCWP: 0.93 X DR-0.15 X SF + 0.03 X(dZ-dA) + 0.87 X E/A + 16.2*	
With 2DE and mitral + Pulmonary venous flow variables in study subjects	
Deceleration rate	0.651
Deceleration rate + Systolic fraction of peak velocities	0.652
Equation *3 PCWP: 1.85 X DR-0.10 X SF + 10.9*	

It was found that PCWP determined by all the equations had significant positive correlation with PCWP measured by catheter (p<0.05) but correlation was stronger with equation 1 (r=0.678) compared with equation 2 (r=0.670) and equation 3 (r=0.652). (Table VII) & (Fig 2-4)

Table VII. Correlation between PCWP determined by three echocardiographic equations and at cardiac catheterization

PCWP (mmHg)	Mean±SD	Pearson Correlation co-efficients (r value)	p value
Invasive (mean)	20.6±3.7	-	-
Non-invasive			
Equation-1	20.2±2.2	0.678	0.001^{S}
Equation-2	22.0±1.8	0.670	0.001^{S}
Equation-3	18.0±2.7	0.652	0.001^{S}

Equation 1 PCWP: 1.43XDR+1.32XE/A-0.024XDT+0.02XMLAV+9.2
Equation 2 PCWP: 0.93 X DR-0.15 X SF+0.03 X (dZ-dA)+0.87 X E/A + 16.2
Equation 3 PCWP: 1.85 X DR-0.10 X SF + 10.9
P value reached from Pearson correlation test
S= significant (p<0.05)

Fig 2: Scatter plot showing correlation between PCWP (mmHg) measured and estimated

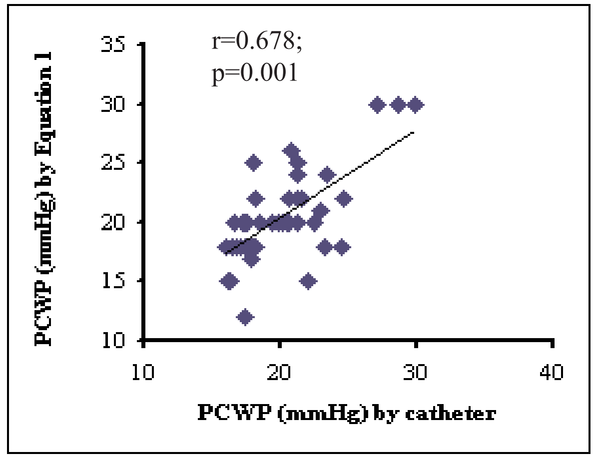


Fig. 3: Scatter plot showing correlation between PCWP (mmHg) measured and estimated

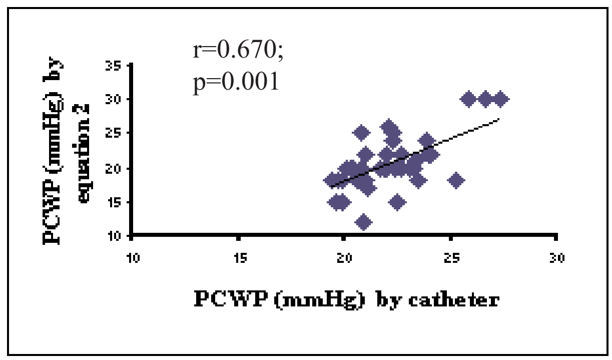
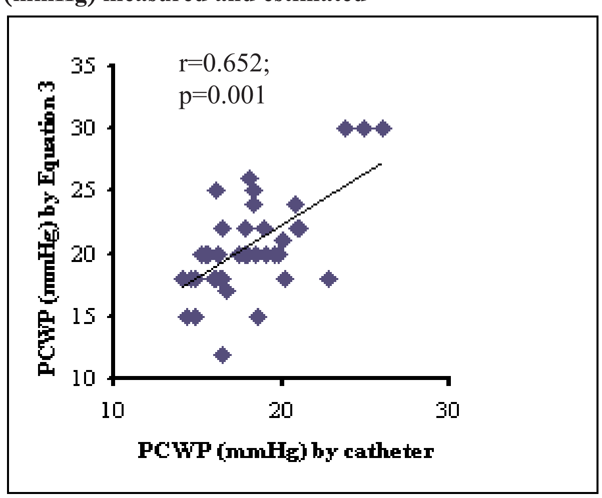


Fig. 4: Scatter plot showing correlation between PCWP (mmHg) measured and estimated



But no statistically significant mean difference was found between invasive PCWP and PCWP by equation 1 (p>0.05), whereas statistically significant mean difference was found between invasive PCWP and PCWP by equation 2 and equation 3 (p<0.05) (Table VIII)

Table VIII: Comparison between PCWP obtained by three echocardiographic equations and at cardiac catheterizations

Parameters (PCWP)	Mean±SD	N	p value
Invasive (mean)	20.6±3.7	50	0.381^{NS}
Equation-1	20.2±2.2	50	
Invasive (mean)	20.6±3.7	50	0.001^{S}
Equation-2	22.0±1.8	50	
Invasive (mean)	20.6±3.7	50	0.001^{S}
Equation-3	18.0±2.7	50	

S= significant (p<0.05)
NS= not significant (p>0.05)

Discussion

Pulmonary Capillary Wedge Pressure (PCWP) can be reliably estimated in patients with different cardiac diseases by combining Doppler echocardiographic variables in multiple regression analysis. The present study was conducted to correlate PCWP estimated by Doppler echocardiography with that obtained at cardiac catheterization in patient with coronary artery disease and to evaluate feasibility & accuracy of Doppler echocardiographic data.

A statistically significant negative correlation of deceleration time (r = -0.483) and ejection fraction (r = -0.334) and significant positive correlation of peak E wave (r = 0.345) and deceleration rate (r = 0.651) were observed with catheter derived PCWP (p<0.05). But no significant correlation was found between catheter derived PCWP and peak A wave, E/A ratio, duration of the late diastolic velocity wave (dA), peak S wave, peak D wave, systolic fraction of peak velocities, duration of reverse flow at atrial contraction (dz), dz-dA and MLAV(p> 0.05).

A study[18] established the positive correlation of peak early mitral flow velocity (E-wave) and mean PCWP (r=0.50) and also deceleration time of early diastolic mitral flow and mitral flow velocity at atrial contraction (A-wave) were inversely correlated with mean PCWP, with correlation coefficient of r= - 0.61 and r= -0.57 respectively. Our findings are very much consistent with these findings, except our study didn't find any correlation with mitral flow velocity at atrial contraction and PCWP. The possible explanation might be inclusion of heterogeneous groups of patients with restrictive cardiomyopathy. We also found significant positive correlation of PCWP with deceleration rate (r=0.651), but didn't find any correlation of PCWP with two other parameters [(r=0.066) and r=0.224)] for E/A ratio and peak A-wave respectively.

Another study[19] showed significant positive correlation between PCWP and E/A ratio (r=0.83) and early diastolic deceleration rate (r=0.80). In addition, that study also established an inverse relation between mean PCWP and mitral flow velocity at atrial contraction, A-wave (r=0.66). Our study didn't find any relationship between E/A ratio and left ventricular end diastolic pressure measured invasively in patients undergoing investigation for CAD which is consistent another study.[20]

That study showed highest correlation of PCWP with E/A ratio (r=0.75), significant correlation with IVRT (r-=-0.55) and A-wave velocity (r=-0.70). Like our study, they found a significant correlation of PCWP with deceleration time of early diastolic mitral flow (r=-0.50) and E-wave (r=0.45) and no significant correlation with A-wave duration (r=0.12 p=0.49). The best correlation was observed with combination of E/A ratio and IVRT in a stepwise multilinear regression equation (r=0.79). In our study, mitral A-wave duration (dA) showed no difference among haemodynamic subgroups (r=-0.184) which is consistent with another study.[21]

This study established strongest correlation of PCWP with deceleration rate followed by deceleration time, peak E wave and ejection fraction and similar findings were observed in previous studies.

In one of the study[4] the most important determinant of PCWP was the deceleration rate, where as peak early to late diastolic velocity ratio, deceleration time and maximal left atrial volume provided a smaller contribution. In their study the correlation coefficient between measured and estimated PCWP from Eq 1 derived from multiple regression analysis was(r=0.84). When pulmonary venous flow variables were included with mitral flow variables into multiple linear regression analysis, the resulting correlation coefficient was (r=0.87; Eq-2). The deceleration rate of early diastolic mitral flow and systolic fraction of pulmonary venous flow were the most relevant determinants of PAWP, whereas a smaller contribution was made by difference in duration of pulmonary venous reverse flow and mitral flow at atrial contraction and by early to late peak diastolic velocity ratio. Correlation was further improved in Eq.-3 excluding the patients with mitral regurgitation, where early diastolic deceleration rate and systolic fraction of pulmonary venous flow were the significant predictor of PCWP. Correlation coefficient was (r=0.89; Eq.-3)[4]

This study evaluated all of the three equations for predicting PCWP in a stepwise multiple linear regression analysis and employed Pearson correlation co-efficient to establish the relationship between catheter derived PCWP and estimated PCWP and also to identify best predictor of measured PCWP. The study found the contributionof different variables in similar order with different r-value in equation 1 with correlation coefficient of (r=0.678; Eq.-1) which was highest according to present observation. In equation 2, deceleration rate was the most relevant determinant of PCWP whereas smaller contributions were made by difference in duration of pulmonary venous reverse flow and mitral flow at atrial contraction and peak early to late diastolic velocity ratio. Correlation coefficient was (r=0.670; Eq.-2). In equation 3, deceleration rate was the only significant predictor of PCWP. The correlation coefficient was (r=0.652; Eq.-3).

By combining pulmonary venous flow variables, the present study did not find any significant contribution of systolic fraction of pulmonary venous flow velocity in Eq.-2 and Eq.-3which is contradictory to another study.[4] The possible explanation is difficulty in recording pulmonary venous flow by transthoracic echocardiography.

In the present study, an attempt was also made to determine directly the Pearson correlation coefficient between PCWP determined by different echocardiographic equations and at cardiac catheterization. It was found that PCWP determined by all equations had significant positive correlation with PCWP measured by catheter (p=0.001) which was consistent with the result of previous study. [4] but the correlation was stronger with Eq.-1 (r=0.678) compared with Eq.-2 (r=0.670) and Eq.-3 (r=0.652). So, accordingly, PCWP can most accurately be measured by combining Doppler derived mitral flow variables and 2D echocardiographic MLAV in a regression equation (Eq-1) but according to another study[4] Eq.-1 was the least accurate and highest correlation was obtained by third equation (r=0.89).

Clinical Implications

The detection of instantaneous changes in PCWP after treatment with inotropic, vasodilatory, or diuretic drugs are important in caring for a patient who is critically ill. Because our index can rapidly track mPCWP, it can be applied to evaluate the effect of drugs influencing the hemodynamics. In addition, the echocardiographic techniques can be applied easily outside of an intensive care department setting, such as at the bedside to evaluate the patients with hemodynamic instability of unknown origin. This simple, repeatable, readily available, non-invasive tool may reduce the need for right heart catheterization and may provide us with a bedside method of estimating and monitoring PCWP. Thereby it will make acute haemodynamic monitoring of unstable patients and haemodynamic follow up of patient with congestive heart failure more comfortable and less expensive.

However, before drawing conclusion, we must address the limitation of the study. One of the most important limitations of this study was difficulty in recording pulmonary venous flow by transthoracic echocardiography. The study didn't include patients with other disease like cardiomyopathy. Accordingly, the result cann't be generalized to other patients with more compromised left ventricular function. The study also didn't measure isovolumic relaxation time which is probably the most sensitive of Doppler indexes in detecting impaired relaxation and significant predictor of PCWP in some studies. We used Cournand catheter to measure PCWP, though it would have been better if we could use Swan Ganz catheter. However, the method is significantly reliable for measuring PCWP. Moreover, due to small sample size there were non-significant results in most instances and lower values of correlation coefficients. and haemodynamic follow up of patient with congestive heart failure more comfortable and less expensive.

Conclusions

The present study provides evidence that in patient with coronary artery disease pulmonary capillary wedge pressure can reliably be estimated by combining Doppler echocardiographic variables of mitral flow and pulmonary venous flow and that mitral flow velocity indexes contributed most significantly to such estimation. Among the mitral flow variables deceleration rate is the most important determinant of PCWP.

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