Assessment of left ventricular diastolic function in patients with complete atrioventricular block undergoing pacemaker implantation

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Left ventricular diastolic function was assessed by Doppler echocardiography in ten patients with complete atrioventricular (AY) block undergoing pacemaker implantation. Left ventricular diastolic inflow signals were recorded as the ventricular rate was gradually inceased. At higher rates total mitral flow remained stable despite markedly increased early diastolic filling. In conclusion, Doppler echocardiography helps to determine the heart rate most suitable for preserving normal left ventricular function. [TurkJMedRes 1996; 14(1):29-33]

Key **Words:** Pacemaker, Diastolic functions

Diastole is composed of early, passive and late, active filling phases. Early diastolic filling wave (EFV) occupies 85% of total diastolic filling in healthy adults without any cardiac disorders. This ratio decreases or reverses with aging, hypertension, atherosclerosis, valvular and myocardial disorders. Thus, the contribution of the atrial contraction to total mitral flow becomes more prominent (1 -4).

As a result of asynchronous atrioventricular (A-V) conduction atrial contraction may be conducted to the ventricle in its absolute refractory period. Early mitral flow decreases as the contribution of the atrial contraction increases. This mechanism plays an important role especially in patients with atherosclerosis and hypertension (1-3,5,6).

Permanent ventricular pacing is indicated in patients with sick sinus syndrome and complete AV block where temporary pacing may be inadequate. There is evidence that some patients do not benefit fixed rate ventricular pacing (1,5,7,8,9).

Inadequate preserve for exercise capacity, interference with native electrical activity are possible explanations. The incidence of atrial fibrillation, flutter and congestive heart failure is high among patients with sinus node disease (5,6,8,9-13).

The aim of this study is to determine the left ventricular function changes by Doppler echocardiography in 10 patients with complete A-**V** block undergoing ventricular pacemaker implantation.

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MATERIALS AND METHODS

Ten patients with complete A-V block were included in his study. Temporary or permanent WI (ventricular activated, ventricular sensed and inhibited) pacemakers were implanted in six female and four male patients with a mean age 70±9.33 years in Firat University. Temporary pacemakers were used in five patients. Three of the latter eight who initially received temporary, were finally converted to permanent pacemakers. The pacemakers used were Medtronic 4012 with bipolar endocardial tined electrode. Doppler echocardiographic studies were performed the day immediately following pacemaker implantation. Toshiba SSH-60 Echocardiography machine with 2.5 MHz. transducer was used for M mode and Doppler measurements.

Heart rates were adjusted from 40 to a maximum of 120 beats / minute (bpm), increasing 10 beats per minute. At each interval peak E, A velocities and E/A ratio was determined at each instant of heart rate variation. The following formulas were used in the calculation of E-stroke volume andE-total inflow per minute.

$$SV_E = JI \times r^2 \times E\ max.$$

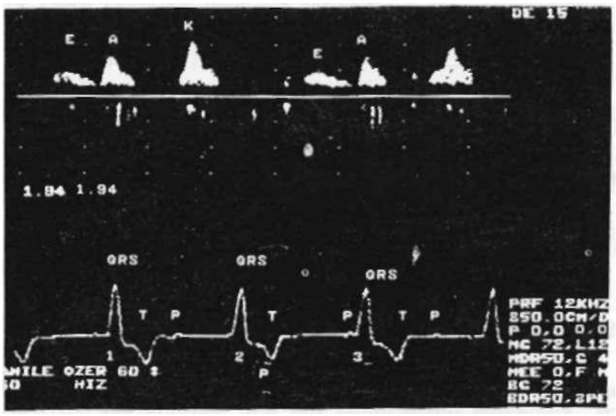

Figure 1. Peak E and A velocities at a fixed heart rate.
a: Early and late diastolic filling properties are normal prior to the first QRS complex.
b: P wave following first QRS complex is superimposed on an early diastolic filling phase resulting in an augmented diastolic filling appearance.
c: There is a P wave in the systolic filling of the second QRS complex. This is within the effective refractory period resulting in no diastolic filling.
d: P wave prior to the third QRS complex has a short PR duration resulting in an incomplete diastolic filling.

Where **SVE**= Stroke volume of E wave; r=mitral valve annulus assuming mitral valve orifice as a circle; A max.=Peak E velocity

TMF$_E$=SV$_E$ x HR.

Where **TMFE**= total mitral flow of E, HR=heart rate.

Number of P waves falling into the **QT** interval was calculated (Figure 1). For this reason the rate of P wave, **QT** and P wave duration, R-R interval observed on the monitor were measured separately rather than using the following formula:

(**QT**+P): R-Rx100

the percentage of the P waves included within **QT** interval was calculated.

Effective atrial contraction number was determined subtracting the number of P waves from the atrial rate per minute. The following formulas were used for the measurement of the stroke volume and cardiac output.

Stroke volume=rc x r^2 x AVM

for the calculation of total minute flow of the A wave:

Total minute flow of A wave = stroke volume of A wave x effective atrial contraction.

The values are recorded as mean ± I SD. Statistical analysis was done using anova and Student's test. p<0.05 considered as statistically significant.

RESULTS

The results are seen in table 1, 2 and 3. Mean EVM values were 0.14 at 40 beats per minute (bpm) (Table 1). At 80 bpm. Mean EVM increased to 0.18 and at 120 bpm. decreased to 0.15 (N.S.) Mean AVM was 0.10 at 40/bpm; 0.12 at 70/bpm; 0.09 at 120/bpm (NS).

Initial A wave occupied %54 (1517 ml.) of the total mitral inflow (Table 1, Figure 2). Initial values decreased to 1235 ml, 732 ml. and 304 ml. at 70; 90 and 120 bpm respectively (<0.001). The decrease of the atrial filling wave principally depend on decreased number of effective P waves, because the variations in mean AVM values related to rate changes was not significant statistically (Table 2,3).

Early diastolic tilling phase is the predominant factor in the generation of total mitral inflow as seen in figure 3. Relative E stroke volume in correspondence lo heart rate variations is presented in Table 2.

At a heart rate of 50 bpm or more, early diastolic filling phase occupies most of the total mitral inflow as seen in Figure 2 and 3. Values of EVM in accordance to heart rate changes are seen in table 1 and Figure 2. The differences in EFW values after 80 bpm. were statistically insignificant (p<0.1).

Table 1. The relationship of filling velocities and E/A ratios to ventricular rate. EVM: Mean filling velocity in early diastole, AVM: Mean filling velocity during active late diastole, E/A: EVP/AVP

Heart Rate	40	50	60	70	80	90	100	110	120
EVM	0.14	0.15	0.16	0.17	0.18	0.18	0.18	0.18	0.15
Anova Test Rate 40-120:		p>0.25							
AVM	0.10	0.12	0.12	0.12	0.11	0.10	0.09	0.09	0.09
Anova Test Rate 40-120:		p>0.25							
E/A	1.24	0.98	1.05	1.08	1.06	1.17	1.22	1.26	1.20
Anova Test Rate 40-120:		p>0.25							

Table **2.** Relationship of E, A and total stroke volume to heart rate. SV-E: Early diastolic stroke volume, SV-A: Late diastolic stroke volume, SV-T: SV-E+SV-A

Heart Rate	40	50	60	70	80	90	100	110	120
SV-E (ml.)	1100	1764	2297	2843	3420	3754	4014	4145	4155
Anova Test									
Rate 40-120		p=0.001							
Rate 60-120		p=0.005							
Rate 70-120		p=0.05							
Rate 80-120		p=0.25							
SV-A (ml.)	1512	1679	1397	1235	982	752	567	406	304
Anova Test:									
Rate 40-120		p=0.001							
Rate 90-120		p=0.005							
Rate 100-120		p=0.25							
SV-T (ml.)	2766	3441	3705	4098	4403	4556	4578	4551	4487
Anova Test:									
Rate 40-120		p-0.1							
Rate 50-120		p=0.25							
Student's t test (P)		0.005	0.025	0.005	0.1	0.1	0.375	0.375	0.375

Table **3.** Effective atrial contraction numbers and AFV/TFV otios relation to varying heart rates. EAC: Effective atrial contraction; AFV/TFV: Stroke volume of atrial systole/total stroke volume (%)

Heart Rate	40	50	60	70	80	90	100	110	120
EAC	66	59	49	43	38	33	28	22	16
Anova Test									
Rate 40-120:		p=0.0001							
Rate 80-120:		p=0.005							
Rate 110-120:		p=0.025							
AFV/TFV	54	47	38	31	22	17	12	9	7
Anova Test:									
Rate 40-120:		p-0.0001							

Cardiac output increment was insignificant at heart rates exceeding 90/minute. At heart rates exceeding 90/bpm, the contribution of atrial filling to total cardiac output decieases significantly (Table 2).

E/A ratio changes were not significant statistically at each increment. The percentage of atrial contribution to toal inflow decreased significantly for every rate change (lable 1, figure 4).

There was a significant correlation between the number of effective atrial contractions and AFV/TFV value. (R-0.974, p<0.0021, table 3, Figure 5).

DISCUSSION

Cardiac output is a primary determinant of peripheral circulation (1,13-16).

Left ventricular diastolic filling is determined by multiple factors. Left ventricular hypertrophy is caused by hypertension, idiopathic hypertrophic subaortic stenosis, aortic stenosis, atherosclerosis which lead to the increased afterload. Thus the disorder of the compliance produced leads to Shift from early diastole to late diastolic period. Consequently, peak flow rate of A wave (AVP) is increased and peak flow rate of E wave (EVP) decreased which results an increase in the AVP/EVP (A/E) and AFV/TFV ratio. Similar changes may occur in mitral stenosis and in elderly. The variation of the heart rate causes changes in the pressure-volume relationship leading to changes in A/E and AFV/TFV ration (10,13,15-19).

Calcium antigonists and nitrates were shown to effect diastolic function in our previous studies (17,18).

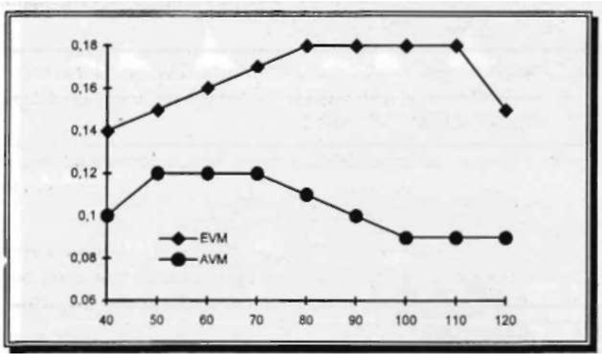

Figure 2. The relationship of filling velocities to ventricular rate. EVM: Mean filling velocity in early diastole, AVM: Mean filling velocity during active. Late diastole

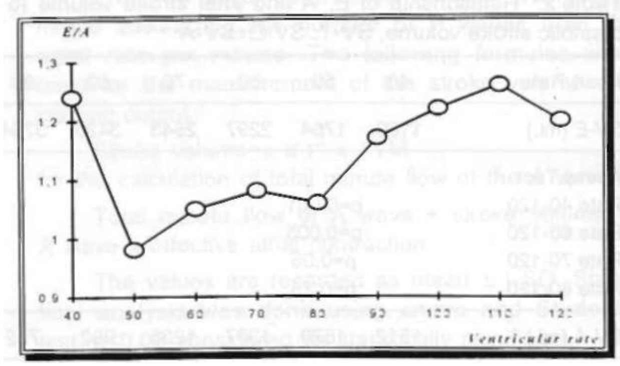

Figure 4. Mean E/A values in varying ventricular rates.

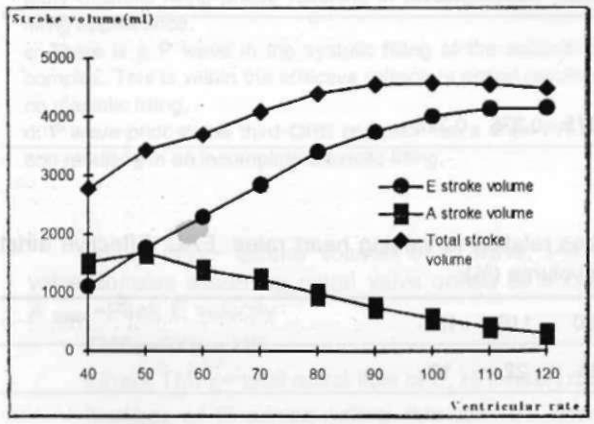

Figure 3. Relationship of E, A and total stroke volume to heart **rate.** E stroke volume: Early diastolic stroke volume, A stroke volume: **Late** diastolic stroke volume, Total stroke volume: Total stroke volume.

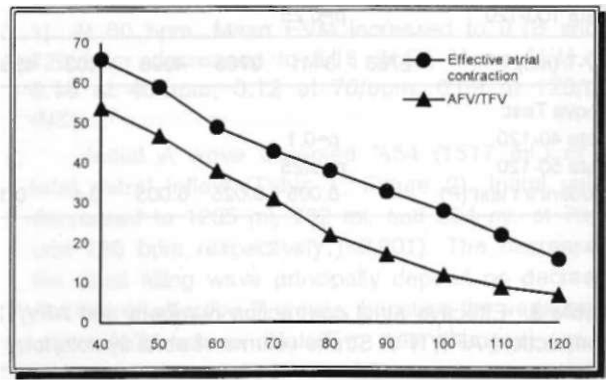

Figure 5. Relationship of ventricular rate to effective atrial contraction and atrial filling to total diastolic filling ratio (AFV/TFV)

It has been shown that atrial contraction contribues to total stroke volume depending on the age and the variety of cardiac disease. Complete heart block decreases atrial contribution resulting in diastolic dysfunction (1,3-6,14,15,20).

VVI and VVIR pacemakers have been shown to induce hemoynamic changes. Activity initiated VVI-RR pacemaker increase heart rate much more prominently compared to VVI during exercise (8,11,12,22,23). On the other hand the increase in cardiac output was insignificant in elderly patients regarding VVI compared to VVI-RR pacemakers. Younger patients could compensate for the absence of chronotropic response to exercise with greater increase in stroke volume. Consequently increased heart rate is insufficient to increase the cardiac output especially in older age groups. Ventricular hypertophy and dilatation, hypertension, atherosclerosis are rarely seen in younger patients. Thus, better cardiac function is expected in younger age groups compared to the elderly. Increased heart rate alters left atrial and pulmonary venous pressures predisposing to congestive heart failure (7,8,11,12,19,21-23).

In conclusion, heart rates exceeding 70/bpm result in hemodynamic disturbance. Doppler echocardiographic examination is necessary in determining the optimal heart rate reulting in normal diastolic function. The ratio of atrial to total mitral inflow must be determined to obtain the best hemodynamic consequences in pacemaker implantation. In patients with rate responsive pacemakers, upper rate of the pacemaker should be programmed to the ideal pace rate as assessed by Doppler echocardiography.

DDD pacemakers should be preferred in elderly in whom atrial contraction is necessary in the generation of cardiac output.

Atrioventriküler tam blok nedeniyle ventriküler pacemaker takılan hastalarda sol ventrikül diastolik fonksiyonlarının değerlendirilmesi

Komplet atrioventriküler blok nedeniyle pacemaker implante edilen 10 hastada sol ventrikül diastolik fonksiyonları Doppler ekokardiografi yöntemiyle incelendi. Ventrikül hızı kademeli bir şekilde arttırılarak sol ventrikül diastolik akım dalgaları kaydedildi. Ventrikül hızı arttırıldıkça erken diastolik akımda artış olmasına rağmen mitral doluşun belli bir hızdan sonra azaldığı tespit edildi. Ventriküler pacemaker takılan hastalarda sol ventrikül diastolik fonksiyonlarının incelenmesinde Doppler ekokardiografi'nin yardımcı olabileceği bu çalışma ile ortaya konuldu.

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