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# The net atrioventricular compliance in mild to moderate hypertensive patients during the early left ventricle filling: A case series

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**Abstract:**

**BACKGROUND:** The compliance is considered **o**ne of the most important parameters which is defined as the change in volume with given change in pressure (dv/dp). It is varying inversely with both diastolic filling and modulus of chamber stiffness.

**AIMS:** This study aimed to deduce the net atrioventricular compliance which is affected the trans mitral blood flow.

**MATERIALS AND METHODS:** This study focuses on study group of 25 patients (15 males and ten females) with mild to moderate hypertension and mean age (49 ± 5.9) who were investigated for atrioventricular compliance and compared with 18 normal individuals (ten males and eight females) with a mean age of (44.9 ± 14.9) years old. The measurement of mitral valve area and the deceleration flow rate during ventricular early filling were taken from peak E wave to the minimum of the descending E wave. The atrioventricular (net) compliance was calculated according to the theoretical calculation Formula.

**RESULTS:** When the atrioventricular compliance is measured during the early filling, a decrease in the net compliance of 50.27% in normal individuals was observed. The isovolumetric relaxation time was lower by 32.9% in normal individuals than in patients with mild to moderate hypertension.

**CONCLUSION:** The increase in the atrioventricular net compliance for hypertensive patients is thought to be attributed to the compensatory mechanism of cardiac muscle before fibrosis can take place leading to a consequent increase in compliance measured during the early diastolic filling stage of the cardiac cycle.

**Keywords:**

Atrioventricular compliance, diastolic filling, moderate hypertension, ventricular early filling

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## Introduction

The effect of hypertension on cardiac performance has been a subject for extensive investigation.[1] These studies involved left atrium function, emptying also left ventricle dysfunction, cardiac hypertrophy, and cardiac compliance.[2] Hypertension is very well known in varying cardiac overload leading to many cardiac diseases and abnormalities.[3] One of the most important parameters among many is compliance which is defined as the change in volume with given change in pressure (dv/dp)[4] is varying inversely with both diastolic filling and modulus of chamber stiffness.[5] The compliance is measured either separately for each cardiac chamber like left atrium or left ventricle alone or combined into net atrioventricular compliance which is affected trans-mitral blood flow.[6]



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It has been reported that sustained volume overload compliance might increase hypertrophy without fibrosis.[7] The importance of cardiac compliance in the assessment of cardiac performance and function is originated from the fact that a loss of compliance causes an increase in muscular stiffness,[8] leading to abnormal changes in the chamber pressure build-up which can influence the blood pressure gradient, blood flow, and eventually cardiac performance.[9] In this study, the net atrioventricular compliance has been calculated on the basis of the theoretical calculation stated by Flachskampf, Weyman,[10] depending on mitral valve area and deceleration flow for patients with mild to moderate hypertension.

## Materials and Methods

### Patients

This study recruited two study groups with a total of 33 individuals: a group of 18 individuals (ten males and eight females) with mean age (44.9 ± 14.9) years old; and a group of 25 patients (15 males and ten females) with mild to moderate hypertension of mean age (44 ± 5.94) years old. Their duration of being hypertensive ranged between (1 and 7) years; they were treated with ß blocker alone or joint with ACE inhibiter. The blood pressure of hypertensive patients was under control during the echocardiography examination as given in Table 1. Patients were chosen with normal ejection fraction and normal valves. The diagnosis for both groups was based on blood pressure, X-ray, electrocardiograph (ECG), and echocardiography.

Echocardiography measurements were taken under quiet respirations with patients laying on the left lateral position using Voluson 530 D equipped with 3 MHz transducer.

Trans-mitral pulsed Doppler was recorded from the apical four-chamber view with the sample volume positioned between the tips of mitral valve to determine the peak early velocity E and deceleration time which is from peak E to the end of the deceleration E wave. Isovolumic relaxation time was also measured; it is taken from aortic closure (the end of flow) to mitral valve opening (the beginning of trans-mitral flow). Left ventricular diameters at the end diastole and the end systole were measured to identify the stroke volume and ejection fraction. The net compliance (Cn) can be estimated from the deceleration rate (dE/dt) of the trans-mitral velocity profile by using the simplified Bernoulli and continuity equation yield to the expression (1):

$$Cn = -1.33\frac{A}{\rho dE/dt,} \quad \text{.....} [11]$$

where (ρ) is the blood density = (1.05 gm/cm$^3$) and A is the mitral valve area with mean value (5 cm$^2$). The net compliance was measured in units of cm$^3$/mmHg according to equation 1 for the two groups, normal individuals and hypertensive patients.

**Table 1: Data taken for patients and controls**

| Patient | | Normal (M±SD) | Hypertensive (M±SD) |
|---|---|---|---|
| Age | | 44.9±14.9 | 49±5.94 |
| Blood pressure | Systole | 12.78±0.87 | 14.1±1.72 |
| | Diastole | 8.3±31 | 8.77±1.28 |
| Height | | 163.35±11.2 | 163.5±11.6 |
| Weight | | 74.1±15.4 | 80±14.9 |
| Body surface area (m$^2$) | | 1.78±0.22 | 1.89±0.18 |

M=mean, SD=standard deviation

### Statistics

All values are expressed as a mean value and standard deviation (M ± SD); an unpaired student t-test was used to test the significance of the difference in mean values for both groups.

### Ethical consideration

The ethics committee in the College of Medicine, University of Baghdad, approved the study proposal. The Ministry of Health (MOH), office of extramural research had certified that the author of this research paper had successfully passed the protecting human research participant course. All the data collection and other research-related activities were designed to respect and protect human rights including confidentiality, voluntary participation, informed consent authentication, study protocol description, participation risks and benefits explanation, and the right to withdraw without prior notice.

## Results

Table (2) indicates that the deceleration rate in normal individuals has a significant increase of 29.78% comparing with hypertensive patients ($P$ <0.05). The results of net compliance revealed a significant decreased of -50.27% in normal individuals comparing with hypertensive patients ($P$ <0.05). Atrioventricular stiffness (the inverse of compliance) revealed a significant increase by 26.66% in normal individuals compared with hypertensive patients ($P$ <0.05) [Table 2]. The disease effect has also been reflected in the isovolumic relaxation time giving a decrease of -32.9% ($P$ <0.05), which highlights a significant difference between normal individuals and hypertensive patients.

## Discussion

The assessment of atrioventricular net compliance via the measurements of mitral valve area and the deceleration rate (dE/dt) taken from peak E descending to minimum E on the mitral Doppler velocity is based on the fact that the higher the deceleration rate is, the slower the filling

**Table 2: Cardiac parameters for normal individual and hypertensive patients**

| Cardiac parameter | Normal individuals | Hypertensive patients | Significance | Change percentage% |
|---|---|---|---|---|
| Early filling velocity E (cm/sec) | 69.1±10.3 | 58.3±12.2 | S | 15.62 |
| Deceleration rate (cm/sec²) | 0.591±0.11 | 0.415±0.11 | S | 29.78 |
| Deceleration time (msec) | 117±15.3 | 147.85±22.8 | S | -26.36 |
| Net compliance Cn (cm≥/mmHg) | 11. ± 2.1 | 16.53±4.9 | S | -50.2 |
| AV stiffness (mmHg/cm≥) | 0.09±0.016 | 0.066±0.02 | S | 26.66 |
| Isovolumic relaxation time (msec.) | 79±10.3 | 105±18.62 | S | -32.9 |
| Left atrium maximal volume (cm≥) | 37.1±11.02 | 45.3±9.55 | NS | -22.1 |
| Left atrium minimal volume (cm≥) | 17.97±6.46 | 23.83±5.38 | S | -32.6 |
| Stroke volume (cm3) | 69.6±16.2 | 69.28±8.1 | NS | 0.459 |
| Left ventricular Fraction % | 61.3±5.8 | 62.4±7.38 | NS | -1.79 |

S=significant, NS=non-significant

rate caused by a rapid reduction in pressure gradient between left atrium and left ventricle; this shows that the left ventricle is less compliant or stiffer.[12] In the theoretical calculation presented in this study, the mitral valve size should be taken into consideration and maintained at same average for patients and controls. This is because this study uses the deceleration rate of the trans-mitral velocity profile which is affected by the mitral valve size (equation 1).[13] The measurement of atrioventricular compliance is rather complex during early diastolic filling.[14] It can give high compliance resulting from the passive blood filling with the ongoing left ventricular relaxation leading to less stress exerted on the left ventricle walls with a large increase in volume causing a large change in volume relative to a small change in pressure and consequent high compliance.[15]

In this study, an increase in net compliance was observed in patients suffering from mild to moderate hypertension. It is expected that a loss of net compliance may ensue as a result of hypertension. However, there are some cases where the left ventricle is subjected to overload and have increased left ventricular operative compliance even in the second mid-diastole than in normal individuals.[16] These results may be related to that when patients with mild to moderate hypertension and fibrosis (caused by increased collagen content in the myocardium) may have not been occurred yet in the cardiac muscle,[17] this will lead to the muscle to reserve its flexibility together with a possible muscle compensatory action for the overload leading to a consequent increase in compliance.[18] These results agreed with the study highlighted that the fat fraction maps that are most frequently obtained using Dixon sequences have regularly demonstrated better sensitivity to conventional functional evaluation and have proven their capacity to identify minute changes in muscle composition.[19] A slight increase, but statistically significant, was observed on the left atrium minimal volume, while the increase is not statistically significant on its maximal volume. This increase in volume in the LA may also influence operative compliance. This also, a mirror of a study result, showed that increased AF burden, LA compliance, and mechanics gradually deteriorate, raising the likelihood of developing new-onset AF and progressive AF. These modifications encourage the emergence of a distinct form marked by increased ventricular interaction, right heart failure, and escalating pulmonary vascular disease.[20]

## Conclusion

In mild to moderate hypertensive patients, the results showed an increased left ventricular operative compliance even in the second mid-diastole than in normal individuals.

### Limitation

The study could include other hypertensive patients with others treated.

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### Conflicts of interest

There are no conflicts of interest.

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