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Original Article

Early diastolic driving force as a new Doppler index for prediction of left ventricular end diastolic pressure

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A B S T R A C T

Background: We thought that the early diastolic driving force (DF) can offer a clinically reliable method to determine left ventricular end diastolic pressure (LVEDP).

Material and methods: One hundred patients were scheduled for estimation of LVEDP by left-sided heart catheterization (LVEDPcath) and Echocardiography, via estimation of the mitral E wave velocity and its deceleration time (DT), to calculate the DF = density × volume × acceleration = 1.055 × (mitral valve area × velocity time integral) × peak E/acceleration time (AT) =1.055 × {(220/P1/2) × (E × AT)/2} × E/AT, if P1/2 = 0.29 DT, and hence DF = 400 E^2/DT = 0.004 E^2/DT Newton. Tissue Doppler estimation of the mitral annular E′ for the E/E′ ratio and septal (E/E′-S) and lateral (E/E′-L) was done.

Results: DF had a negative correlation ($r = -0.63$, $P < 0.001$), but E/E′-L and E/E′-S had positive correlations ($r = 0.87$ and 0.85 respectively, $P < 0.001$) with LVEDP. At a cutoff value of 0.1 N, DF had a sensitivity of 94.1%, specificity of 86.7%, to determine LVEDP > 16. E/E′-L is more sensitive and more specific than E/E′-S (72.9% and 93.3% vs. 58.8% and 86.7%) in prediction of LVEDPcath. DF is the almost powerful independent predictor of LVEDPcath ($P = 0.002$). DF had a coefficient = 0.619 ($P < 0.001$) for estimation of the LVEDP in the gray zone.

Conclusion: Early diastolic DF could be used as a reliable index for elevated LVEDP, especially in the gray zone.

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1. Introduction

Left ventricular (LV) heart failure with preserved LV ejection fraction "diastolic heart failure" makes up to 50% of heart failure.[1] Echocardiographic indices are critically dependent on ventricular filling pressure.[2] "Impaired relaxation" refers to a prolonged *t*1/2.[3] It results in prolonged isovolumic relaxation time, a slower rate of decline in ventricular pressure, and a consequent reduction in the early peak-filling rate.[4] The LV end diastolic pressure (LVEDP) estimation assesses the hemodynamic severity, so it evaluates the cardiac dysfunction and helps in the proper management and therapeutic interventions. LVEDP can be assessed by different techniques, both invasive (cardiac catheterization) and noninvasive (echocardiographic Doppler) approaches.[5] The main advantage of Doppler measurements is their ability to calculate hemodynamic indices noninvasively and estimate the early diastolic indices at the same time.[6]

The aim of the study was to assess how the early diastolic driving force (DF) is valid as a new index for prediction of LVEDP using LV end diastolic pressure measured by cardiac catheterization (LVEDPcath) as a reference.

2. Material and methods

This study had been carried out in our Cardiology Department, Zagazig University Hospitals, Egypt. It has been approved by the ethical committee and informed consent was obtained from the patients after explaining the procedure of the study. It is a retrospective study that included 100 consecutive patients scheduled for coronary angiography and left-sided heart catheterization to measure LVEDP regardless of their diagnosis, just to test the new equation designed for estimation of LVEDP and comparing it with the commonly used E/E′ tissue Doppler method and weighing both methods on the gold standard invasive reference. Patients with atrial fibrillation, left bundle branch block, mitral and/or aortic prosthesis, mitral stenosis, mitral calcification, more than mild valvular regurgitation, pericardial diseases, and contraindications to dye were excluded from the study.

All participants were subjected to the following:

1. Complete history taking and thorough clinical examination.
2. Electrocardiographic examination (ECG).
3. Echocardiographic study

Transthoracic echocardiographic examination was done by using HP Sonos 5500 set with a 2.5 MHz transducer. Images were taken during the time that the patient was in supine or in the left lateral position using left parasternal long axis and apical 4 chamber views. Recordings and calculations of different parameters were done according to the recommendations of the American Society of Echocardiography[7] within 24 h before catheterization. The following measures were stressed upon and selected for analysis:

2.1. 2-D echocardiography

Ejection fraction (EF%): calculated from the apical 4- and 2-chamber views with Simpson's method. EF = {EDV − ESV}/EDV × 100.

2.2. Pulsed wave Doppler imaging of the transmitral flow

Sample volume was positioned at the tip of the mitral leaflets where the velocity amplitude is maximal in the apical four-chamber view, to measure E wave velocity, E wave deceleration time (DT), defined as the time-interval between peak of E wave and the point where the descending limb touches baseline. The sweep speed was adjusted at 50–100 mm/s and the measures were taken at end expiration.[8]

$$\begin{aligned}\text{Early diastolic driving force (DF)} &= \text{mass}\times\text{acceleration.}\\ &= \text{density}\times\text{volume}\times\text{acceleration}\\ &= 1.055\times\{\text{MV area}\times\text{velocity time integral}\}\times\text{peak E/acceleration time(AT)}\\ &= 1.055\times\{(220/\text{P1/2})\times(\text{E}\times\text{AT})/2\}\times\text{E/AT.}\end{aligned}$$

*To derive pressure half time (from Fig. 1)

ac = peak E, ce = pressure half time (P1/2), cf = deceleration time (DT).

Therefore; ab/ac = ce/cf ***or*** $\left(E - E/\sqrt{2}\right)/E = P1/2/DT$

If the P1/2 = DT × E (1 − 1/1.4)/E, ***or*** 0.29 DT.

Then DF = 1.055 × (220/0.29 DT) × (E × AT/2) × E/AT.

($Gm/cm^3 \times cm^2 \times cm\text{-}s \times cm/s^2$) = 400 E^2/DT **K dyne or** 0.004 E^2/DT **Newton**, for blood flowing through the mitral inlet, with a mass equal to a column with a length and a circular cross sectional area equal to the mitral valve area.[1]

We all know that LV volume, mass, and LA volumes are major determinants of diastolic function, but the main interest of this work was, just, estimation of EDP and not diastolic function.

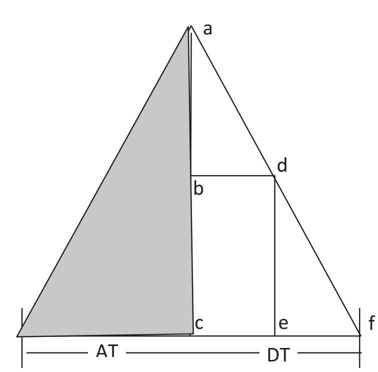

Fig. 1 – Diagram of early diastolic transmitral velocity E wave. E = amplitude of peak velocity. AT = acceleration time, DT = deceleration time.