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Assessment of Diastolic Behavior of Patients with Hypertension vs. other Myocardial Diseases Using an External Pressure Transducer and Short Handgrip Exercise

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Left ventricular (LV) diastolic abnormalities (LVDA) represent the earliest manifestation of most myocardial diseases. Especially, LVDA precede in arterial hypertension (HTN) the development of LV hypertrophy [1] as well as LV systolic dysfunction [2].

It has been excessively shown that although the use of both pressure sensors and volumetric techniques represents the ideal method for assessing diastolic dysfunction, LV pressure (LVP) derived diastolic measures are widely accepted and almost exclusively used as standard. Therefore, the widely applied Doppler echocardiographic diastolic indexes are expected to represent as volumetric variables only dubious estimates of diastolic LVP changes [3] showing profound limitations for assessing noninvasively LV diastolic dysfunction.

Pressocardiogram

Pressocardiogram is a very old noninvasive technique that has been used widely in noninvasive laboratories in and out of hospitals by applying transthoracically an optimal pressure sensor over the maximal LV impulse. It has been proved that this pulse pressure tracing obtained over the maximal LV impulse reflects LVP curve in time and slopes [4]. Moreover, several pressocardiographic temporal and relative amplitude indexes have been found to correlate significantly with corresponding widely accepted diastolic measures derived from high-fidelity LVP curve recordings [5-7]. The most frequently used indexes are the total relaxation time from the begin of 2nd heart sound in phonocardiogram to the lowest point of Pressocardiogram [5] and the relative A wave to total pressocardiographic height [6,7].

Diastolic Stress Test Using Pressure Sensors

It has been shown that Diastolic LVP curve changes occur with exercise earlier than any systolic or ECG abnormalities and are characteristically of high magnitude in presence of inducible ischemia [8,9]. A pressocardiogram can be optimally obtained simultaneously with phonocardiogram by placing and fixing an optimal pulse pressure sensor and a heart sound microphone transthoracically with a 2 min isometric handgrip exercise - termed now Presso Test. Presso Test's positivity could be for the first time exactly defined in ambulant patients with angina pectoris [10,11]. Subsequently, Presso Test's clinical value has been explored in detecting patients with various myocardial diseases in daily practice and the normal limits of some early and late diastolic indexes at rest and with handgrip exercise have been defined in a large group of healthy volunteers. Above, some differences in diastolic behavior among patients with various myocardial diseases could be for the first time exactly defined. Specifically, some characteristic differences in the pattern of exercise-induced early and late LVDA could be further analyzed and defined in ambulant [10-12] or hospitalized [13] CAD symptomatic or asymptomatic patients as well as HTN patients at rest [14] or with handgrip [15-17] and cardiomyopathy patients [17,18].

Most importantly, some significant differences have been found comparing the handgrip-induced LVDA in HTN with those found in CAD or other myocardial diseases. Specifically, the distribution of patterns and forms of diastolic behavior that we found using Presso Test in HTN [13-16] differs significantly from that found in CAD [13-15] or hypertrophic cardiomyopathy patients [18] and may be used for differentiating at least partly these myocardial diseases even in earlier stages [17].

Diastolic Types, Patterns and Forms of Presso Test

Some diastolic types, patterns and forms could be exactly defined using Presso Test. A positive Presso Test is defined by the presence of either an abnormal Relaxation time (Relaxation type) or relative A wave rise (Compliance type) or both (mixed type) with handgrip exercise. The relaxation type has been found to be associated with a more favorable and the compliance type with the worst outcome; therefore, we named the sequence R->RC-> C-types as a "deterioration of type" [19].

Most importantly, we could differentiate further an *ischemic* from a *non-ischemic* diastolic pattern [12], whereas the former was characterized by exactly definable high-magnitude diastolic abnormalities, which are very similar with those found in catheterization studies using micro manometers in left ventricle in presence of inducible ischemia with exercise [8,9].

Based on some characteristic differences in LV diastolic behavior found in patients with various myocardial diseases states [16,17] four 4 Differential Forms (DFs) could be for the first time defined [20]. As shown in Figure 1, the "Hypertensive DF (*Htn-DF*) is defined by only slight LVDA in all stages of handgrip and is predominantly present in

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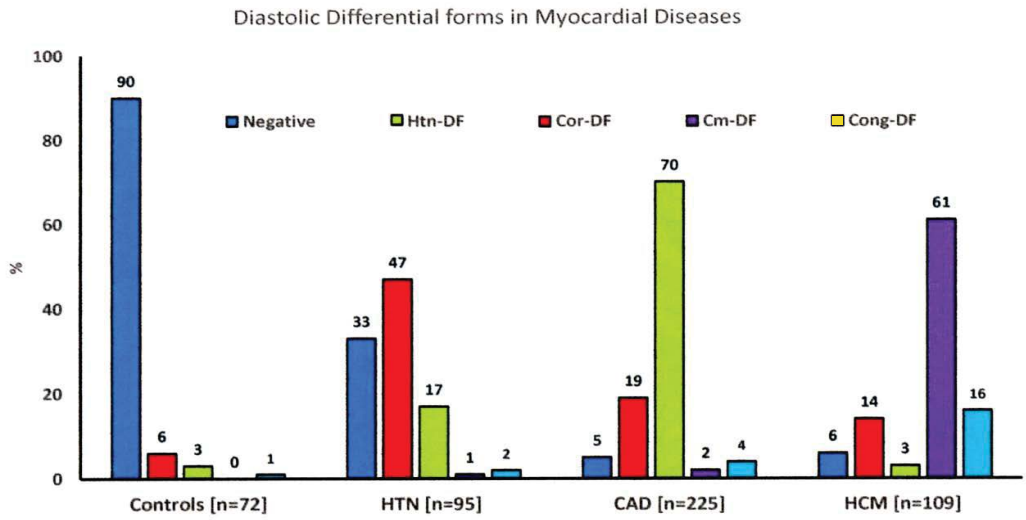

Figure 1: Prevalence of diastolic Differential Forms (DFs) based on Presso Test data in controls as well as in patients with arterial hypertension (HTN), coronary artery disease (CAD) and hypertrophic cardiomyopathy (HCM). Negative = all diastolic pressocardiographic data within normal limits; Htn-DF = Hypertensive DF; Cor-DF = Coronary DF; Cm-DF = Cardiomyopathic DF; Cong-DF = Congestive DF (*modified from Manolas J, Eur Heart Failure J, 2009* [17]).

hypertensives. In contrast, a Coronary DF (*Cor-DF*) is characterized by an ischemic pattern associated with a deterioration of diastolic type, whereas Cardiomyopathy DF (*Cm-DF*) by high-magnitude LVDA predominantly of relaxation time and a Congestive DF (*Cong-DF*) by a significantly elevated relative A wave already at rest.

As shown in Figure 1, a normal response or negative Presso Test was present in 90% of healthy subjects and in about 1/3 of HTN patients [15,16] and was significantly more frequent in hypertensive's than in CAD or HCM patients [16]. In contrast, a *Cor-DF* was present in 2/3 of CAD, but is very rare in controls or HCM patients [17]. In HTN patients, a *Cm-* or *Cong-DF* were very rare and a *Cor-DF* has been found in about 1/10 of them [16]. In a small observational study, hypertensives with a Cor-DF showed clinical or angiographic evidence of significant or nonsignificant coronary stenoses [16].

Limitations of Presso Test

This simple tool is widely applicable not only in hospitals or diagnostic centers, but almost everywhere -incl. patients home- as initial screening tool, since it can be obtained by mobile devices too and it is convenient for every subject - including disabled and very elderly; whereas no life threatening arrhythmias or infarction has hitherto been observed. However, Pressocardiogram cannot be obtained in 5-10% of subjects, who do not show a clearly palpable precordial impulse. Most importantly, this simple tool needs to be applied and tested in much more centers and countries and in very large populations. It should also be compared with presently routine diagnostic tools -like coronary calcification and computer tomographic angiography etc. In contrast to the latter, however, Presso Test can be obtained everywhere by every non-expert and clearly less expensive.

Conclusion

Presso Test represents a simple diastolic stress test that might become a useful simple diagnostic tool in daily practice for evaluating patients with HTN and other myocardial diseases. About the half showed only slight diastolic abnormalities with handgrip and about 1/3 had a normal diastolic response. However, about 2/10 of hypertensives showed a characteristic ischemic diastolic response and had clinical or anatomic evidence of CAD. Therefore, hypertensives with a so-called "coronary differential form" of Presso Test should be further examined for the presence of a potentially associated occlusive or not even and asymptomatic CAD. Moreover, a Presso Test in hypertensives might be also useful in detecting a deterioration of LV function or beginning of a heart failure with preserved ejection fraction as well as in evaluating the effects of antihypertensive drugs on LV function.

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