EDITORIAL

The Importance of Volumetric Stress Echocardiography: the Contractile Reserve in the Stress Echo Lab

La importancia de la ecocardiografía volumétrica de estrés: la reserva contráctil en el laboratorio de Eco Estrés

LAURO CORTIGIANI[1]

LEFT VENTRICULAR VOLUMES: TOO BORING TO MEASURE?

Quantitative measurements of left ventricular (LV) end-diastolic volume (EDV) and end-systolic volume (ESV) are not routinely employed in many laboratories since they are time-consuming and not so reproducible for image degradation during stress. Ejection fraction (EF) is usually accurately estimated by eyeballing but the measurement of LV volumes requires a quantitative assessment with endocardial border delineation of LV planimetry by hand (1). Yet, good pathophysiological reasons and recent technological innovations make such measurements simpler and more reliable.

LV CONTRACTILE RESERVE: THE PATHOPHYSIOLOGICAL RATIONALE

LV contractile reserve can be obtained as the increase from rest to stress in load-dependent EF, or a geometry-independent, quantitative, global longitudinal strain which is however limited by high heart rate during stress. According to Marwick 2022, "*perhaps the best way to integrate the role of loading in the evaluation of LV function is to ensure that the measurement of blood pressure should be included in imaging studies that could be used clinically to estimate contractility*" (2). Elastance (also known as Force) does that (3, 4). Similar information can be obtained with other indices assessing the global contractile reserve independently of regional function, from stroke volume to cardiac output to cardiac power. There is more information in the assessment of global LV performance that can be detected simply with regional wall motion abnormalities. From a pathophysiological perspective, this is not surprising. The perfusion of the subendocardial layer is linked to regional wall thickening and regional wall motion abnormality, but a scar, necrosis, or subepicardial layer damage do not affect changes in regional wall motion. The subendocardial layer develops intracavitary and systolic blood pressure (SBP), and the subepicardial layer has an anti-remodeling, volume-reducing, effect. Therefore, myocardial damage or ischemia can be missed by regional wall motion abnormality and detected as a lower force reserve since a diseased myocardium develops less force (SBP/ESV). Subendocardial damage develops lower SBP. Subepicardial damage is associated with a higher ESV for each level of SBP. This is true even at rest, and we know for 50 years that for every level of EF, higher ESV and lower SBP at rest correspond to a worse prognosis. The same happens during stress.

LV CONTRACTILE RESERVE: THE TECHNOLOGY PUSH

EDV, ESV, and EF are part of the minimum data set recommended during Stress Echo for the detection of coronary artery disease, and outside coronary artery disease. However, analysis is usually qualitative with side-by-side comparison, without measurement. As a result, mostly qualitative patterns have been identified, with the normal response characterized by an increase in EDV and a decrease in ESV during stress, with an increase in EF. The identification of the endocardial contour of the left ventricle can be easier, faster, and more precise with ultrasound-enhancing agents, real-time 3-dimensional echocardiography, and artificial intelligence. The time for automated, precise, reproducible, click-free calculation of LV volumes has come. No more boring, time-consuming, imprecise planimetric calculations. Without tedious effort, we have real-time calculations of EDV (an index of preload reserve), ESV (an index of contractile reserve), and cardiac output (an index of cardiac reserve). The reduction of the cardiac reserve is a common condition, can occur in the absence of regional wall motion abnormalities, and recognizes 3 different hemodynamic phenotypes: chronotropic insufficiency (reduction of heart rate reserve by 1-lead electrocardiogram), preload insufficiency (lack of increase in EDV at intermediate stages of stress), inotropic insufficien-

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Address for reprints: Lauro Cortigiani. San Luca Hospitalm Via Guglielmo Lippi Francesconi. 55100 Lucca – Italy. E-mail: lacortig@tin.it

[1] Cardiovascular Unit, San Luca Hospital, Lucca, Italy

cy (blunted force reserve with lack of ESV reduction). This parameter is universal (does not require proprietary technology), omnivorous (important for all patients, from chronic coronary syndromes to heart failure), and ecumenic (applied to all stresses, from exercise to dobutamine to vasodilators, obviously with different stress-specific cutoff values) (5, 6).

STRESS ECHO 2.0: ANOTHER BRICK IN THE WALL

The Argentinian echocardiographic community is at the leading edge of innovation for decades. The regional wall motion abnormality is the cornerstone of stress echocardiography and was upgraded 20 years ago by the addition of coronary flow velocity reserve in the left anterior descending coronary arteries. After decades from the 2003 pioneering experience of the group of Jorge Lowenstein (7), coronary flow velocity reserve of the left anterior descending with transthoracic Doppler echocardiography is recommended (class 2b) by the 2021 American College Cardiology/American Heart Association guidelines in INOCA patients (8). After 20 years, the same Lowenstein group identifies another game-changer, the global LV contractile reserve, beyond EF. The elastance reserve during exercise identifies troublemakers missed by regional wall motion abnormalities and EF, allows better phenotyping of the patient, and improves risk stratification. The fourth wave of innovation improves the versatility and performance of stress echo: after regional wall motion abnormality, coronary flow velocity reserve, B-lines, now LV contractile reserve with automated volumetric Stress Echo. The required images are the same acquired and stored for analysis in regional wall motion, and there is no increase in imaging and analysis time with the automated approach. Stress Echo is able to capture the many aspects of the prognostic vulnerability of the contemporary patient and does it with a technique run by cardiologists living an imaging experience, with affordable costs, ionizing radiation-free, near zero environmental impact, and unique versatility and sustainability (9). Once again, the group of Jorge Lowenstein from Buenos Aires showed to the entire scientific community that this conceptual and clinical upgrade can take place in a clinically oriented, busy environment, and simple pathophysiological concepts coupled with state-of-the-art technology can bring surprising dividends to the patient (10). Hopefully, the uptake of this important concept by mainstream cardiology will take less than 20 years.

Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web/Additional material.)

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