methods (p = 0.007). Without time-phase shift, correction mean differences were 6.3 with limits of agreement between -14.44 and 20.73 mm Hg.

Comparison between echocardiography and catheterization resulted in a lower coefficient of determination ($R^2 = 0.04$; p = 0.398) and significantly higher mean differences of 19.25 mm Hg without equivalence (p = 0.832). Blood pressure gradients also resulted in a low coefficient of correlation ($R^2 = 0.28$; p = 0.014) with mean differences of -8.44 mm Hg without equivalence (p = 0.197).

TCPM shows good agreement with heart catheterization. The results also confirm that arm-leg measurements tend to underestimate and echocardiography as well as uncorrected pressure mapping to overestimate pressure gradients.

The reliable use of pressure mapping and novel TCPM will depend on availability, resolution, and quality of CMR data. Patients underwent conscious sedation during catheterization, which is known to affect hemodynamics, whereas there was no sedation during CMR, echocardiography, and cuff measurements. Additionally, CMR and echocardiography were not performed simultaneously to catheterization. Nevertheless, the proposed CMR-based TCPM method provides significant equivalence with invasive heart catheterization in contrast to echocardiography and cuff measurements, in which data show large and relevant deviation.

At centers where 4-dimensional velocity-encoded CMR is available, it can already provide additional guidance before invasive procedures are performed. Beyond CoA, TCPM measurements are robust and carry the promising potential for other stenotic diseases, such as aortic valve disease or pulmonary artery stenosis, in which current noninvasive clinical techniques face similar diagnostic challenges. In CoA, TCPM may help to avoid invasive diagnostic procedures in the future. Clinical validation is the first step to bring modelling approaches to the bedside. Further steps of translation include randomized controlled and multicenter clinical trials in larger cohorts.

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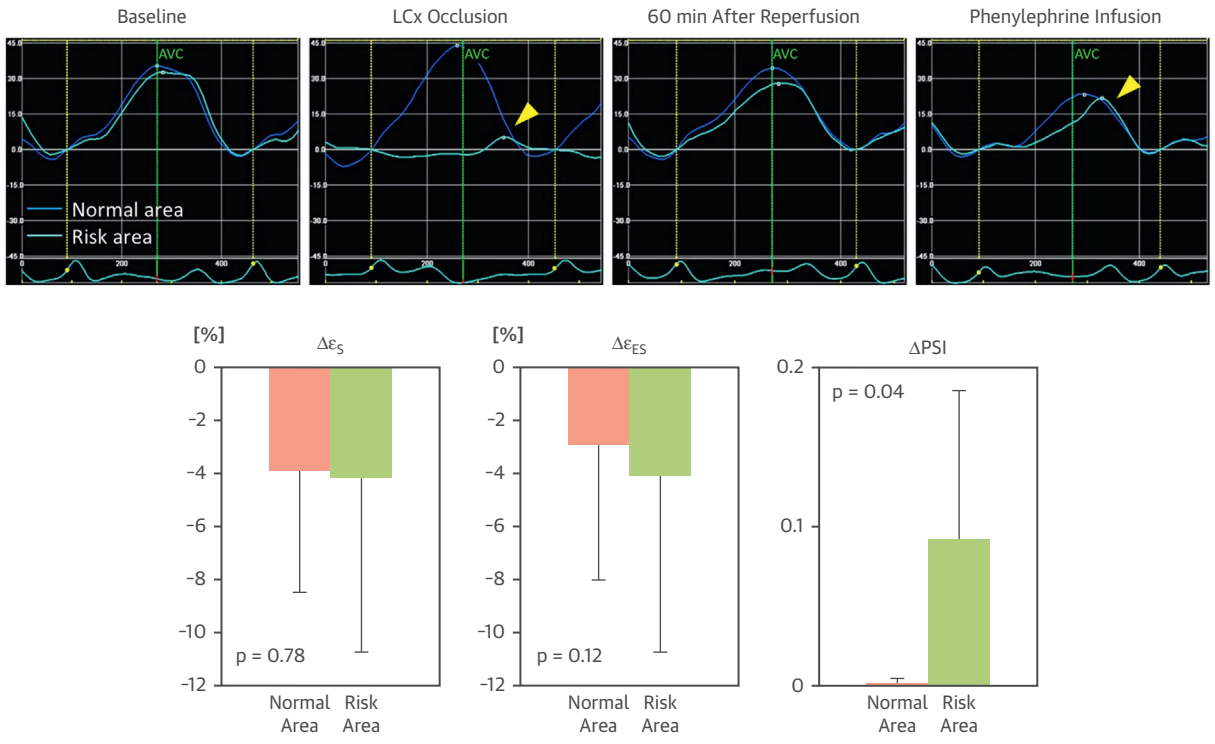
Afterload Augmentation Can Reveal Concealed Myocardial Ischemic Memory

Imaging technology capable of detecting myocardial ischemic memory is desired because angina is often temporary. Post-systolic shortening (PSS) is myocardial shortening after aortic valve closure, which is easily measured via speckle-tracking echocardiography and is a known sensitive marker of acute ischemia (1). A relative decrease in regional contraction generates an imbalance of tension between the ischemic and surrounding myocardium, resulting in PSS. Assessment of PSS can be used to detect myocardial ischemic memory because it persists even after transient ischemia (2,3). However, its persistence is not always long enough, thus hampering its clinical application.

An increase of afterload affects myocardial deformation and makes PSS prominent (4). We therefore hypothesized that afterload augmentation could reveal concealed ischemic memory after transient ischemia and evaluated whether brief afterload augmentation allows the reappearance of PSS that had disappeared after transient ischemia.

FIGURE 1 Representative Strain Profiles and Changes in Strain Parameters Before and After Phenylephrine Infusion



In the risk area, systolic strain decreases and post-systolic shortening (PSS) **(yellow arrowhead)** occurs during left circumflex coronary artery (LCx) occlusion, but systolic strain returns to the baseline level and PSS disappears 60 min after reperfusion. After phenylephrine infusion, PSS reappears in the risk area but not in the normal area. The differences in peak systolic strain ($\Delta\varepsilon_S$) and end-systolic strain ($\Delta\varepsilon_{ES}$) are not significantly different in the normal and risk areas. However, the difference in the post-systolic strain index (ΔPSI) increases significantly in the risk area compared with the normal area. AVC = aortic valve closure.

In 7 anesthetized dogs, the left circumflex coronary artery (LCx) was occluded for 2 min, followed by reperfusion. Phenylephrine infusion (1.0 μg/kg/min) was started 60 min after reperfusion for brief afterload augmentation, and short-axis images (Vivid 7, GE Vingmed Ultrasound AS, Horten, Norway) were acquired at baseline, at the end of occlusion, at every 10 min until 60 min after reperfusion, and at 10 min after phenylephrine infusion. At the end of the protocol, real-time myocardial contrast echocardiography was performed during transient LCx occlusion to confirm the risk area. Radial strain profiles were analyzed in the centers of the normal and risk areas (EchoPAC BT11 software, GE Vingmed Ultrasound AS). Peak systolic strain (ε_S), end-systolic strain (ε_{ES}), and the post-systolic strain index (PSI) as a parameter of PSS were measured (3), and the difference (Δ) in each parameter before and after phenylephrine infusion was calculated.

The results showed that ε_S and ε_{ES} were significantly decreased in the risk area during LCx occlusion, but they recovered to the baseline level 10 min after reperfusion. However, PSI tended to remain higher than the baseline level until 30 min after reperfusion, and then it returned to the baseline level (baseline: 0.04 ± 0.04; occlusion: 0.65 ± 0.18; 10 min after reperfusion: 0.16 ± 0.10; 20 min: 0.09 ± 0.07; 30 min: 0.07 ± 0.07; 40 min: 0.03 ± 0.03; 50 min: 0.04 ± 0.05; and 60 min: 0.03 ± 0.04).

After phenylephrine infusion, left ventricular systolic pressure increased significantly compared with before infusion (112 ± 10 mm Hg vs. 141 ± 16 mm Hg; $p < 0.05$). In the strain analysis, PSS reappeared in the risk area but not in the normal area. All data showed that $\Delta\varepsilon_S$ and $\Delta\varepsilon_{ES}$ were not significantly different in the normal and risk areas, although $\Delta\varepsilon_{ES}$ tended to be larger in the risk area. However, ΔPSI increased significantly in the risk area compared with the normal area (**Figure 1**).

The duration of myocardial ischemic memory is important for clinical applications. The persistence of PSS after transient ischemia is 20 to 30 min or less,

except in cases of severe supply ischemia (2,3). Although this duration is valuable for stress echocardiography, it seems to be short to use for ischemic memory imaging. However, a latent decrease in myocardial contractility due to ischemia may continue for a while even after normalization of the strain profile.

In the present results, brief afterload augmentation allowed reappearance of PSS that had disappeared after transient ischemia. We believe that the relative decrease in ε_{ES} is a main mechanism of the reappearance of PSS during afterload augmentation. The present study suggests that this technique can reveal concealed myocardial dysfunction and may be useful for ischemic memory imaging via speckle-tracking echocardiography.

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Early Changes in Myocardial Mechanics Detected by 3-Dimensional Speckle Tracking Echocardiography in Patients Treated With Low Doses of Anthracyclines

Cancer therapy-related cardiac dysfunction (CTRCD) represents an important cause of morbidity and mortality; early detection along with cardioprotection are fundamental to improve prognosis (1). However, usual diagnostic parameters have low sensitivity, increasing interest for early markers of CTRCD (1). A 3-dimensional speckle tracking echocardiography (3D-STE) has revealed more consistent data than a 2-dimensional (2D) technique and may prove to be more accurate in patients undergoing chemotherapy (2). This prospective study investigated myocardial deformation using 3D-STE in patients with breast cancer treated with low doses of anthracyclines to identify early markers of cardiotoxicity.

Patients >18 years of age, newly diagnosed with breast cancer, and scheduled for chemotherapy with anthracyclines were eligible. Exclusion criteria included previous chemotherapy or radiotherapy, inadequate echocardiographic imaging (>2 non-visualized segments) and a left ventricular ejection fraction (LVEF) <55% before chemotherapy. Patients underwent a comprehensive echocardiogram and collection of ultrasensitive troponin I (US-TnI) during the following 3 stages: at baseline and after non-liposomal doxorubicin cumulative dosages of 120 and 240 mg/m^2. We analyzed the LVEF (Simpson's method), 2D global longitudinal strain (GLS), and 2D midpapillary radial strain (RS); for 3D-STE, we measured 3D-GLS, 3D-global RS, global circumferential strain (3D-GCS), and global area strain (3D-GAS) along with rotation, twist, and torsion. Variables were compared among evaluation stages using generalized estimating equations with normal distribution and identity link function followed by multiple Bonferroni comparisons. Due to the asymmetric distribution, for US-TnI, the logarithmic function was used.

A total of 47 patients were eligible for the study, with 3 exclusions (2 due to inadequate echocardiographic images and 1 noncardiac-related death). Forty-four female patients 48.7 ± 10.8 years of age were evaluated, with results summarized in **Table 1**. The mean LVEF was unchanged during treatment; however, the 2D-GLS decreased only after the 240 mg/m^2 dose ($p = 0.001$), with no changes after a lower dosage of doxorubicin (120 mg/m^2). The 2D-RS was similar during both stages. After a dose of 240 mg/m^2 of doxorubicin, 3D-STE detected changes in most myocardial deformation parameters: 3D-GLS, 3D-global RS, 3D-GCS, and 3D-GAS; no changes were observed for rotation, torsion, or twist. After a lower dose of doxorubicin, the only parameters that changed were 3D-GCS ($p = 0.021$) and 3D-GAS ($p < 0.001$). Twenty patients (45%) presented with a US-TnI of >34 pg/ml after a doxorubicin dose of 240 mg/mg^2 ($p = 0.001$); however, a lower doxorubicin dose produced no change in US-TnI.