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## Hyperventilation-breath-hold maneuver to detect ischemia by strain-encoded CMR: a pilot study to evaluate a needle-free stress protocol

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**Background:** Safety concerns for gadolinium-containing contrast agents and pharmacological stressors, together with tremendous costs and inconsistent reimbursement modalities are still limiting a widespread application of CMR stress testing despite proven benefits. Like the effect of adenosine, hyperventilation-breath-hold-maneuver (HVBH) has demonstrated to induce myocardial vasodilation and might serve as a stressor to induce coronary steal with consecutive hypokinesia.

**Purpose:** To evaluate the diagnostic accuracy of a needle-free, ultrafast stress test to detect myocardial ischemia by strain-encoded CMR (fSENC) after HVBH.

**Methods:** Patients referred for CMR stress testing underwent an extended protocol in order to evaluate three different stress forms: (1) Adenosine first-pass perfusion (Ad-FPP), (2) Adenosine-fSENC (Ad-fSENC) and (3) HVBH-fSENC. Diagnostic accuracy was assessed using quantitative coronary angiography as reference.

**Results:** One-hundred-twenty-two predominantly male patients (age  $66 \pm 11$  years; 80% men) suspected for obstructive CAD were enrolled. Ad-fSENC and HVBH-fSENC provided significantly better diagnostic accuracy than Ad-FPP, both on a patient-level (Ad-fSENC: sensitivity 82%[65-93], specificity 83%[73-90],  $p < 0.05$ ; HVBH-fSENC: sensitivity 81%[64-93], specificity 86%[77-93],  $p < 0.05$ ) and territory-level (Ad-fSENC: sensitivity 67%[52-80], specificity 93%[90-96],  $p < 0.05$ ; HVBH-fSENC: sensitivity 63%[47-76], specificity 95%[91-97],  $p < 0.05$ ). The stress response of longitudinal strain differs significantly between ischemic and non-ischemic segments to Adenosine (LSischemic =  $0.6 \pm 5.4\%$ , LSnon-ischemic =  $0.9 \pm 2.7\%$ ,  $p < 0.05$ ) and HVBH (LSischemic =  $1.3 \pm 3.8\%$ , LSnon-ischemic =  $-0.3 \pm 1.8\%$ ,  $p = 0.002$ ). Stress test duration of HVBH-fSENC ( $t = 64 \pm 2$  s) was significantly shortened compared to Ad-fSENC ( $t = 184 \pm 59$  s,  $p < 0.0001$ ) or Ad-FPP ( $t = 172 \pm 59$  s,  $p < 0.0001$ ).

**Conclusions:** Stress testing by HVBH-fSENC provides promising diagnostic accuracy to detect myocardial ischemia and is faster than established methods without the necessity to apply contrast agent or pharmacological stressors.