Novel diagnostic procedure

Hyperventilation and cold-pressor stress echocardiography combined with automated functional imaging non-invasively detected vasospastic angina

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Summary

A 47-year-old male presented with chest discomfort while sleeping. The patient was suspected of having vasospastic angina (VSA) and underwent hyperventilation and cold-pressor stress echocardiography. No chest pain, ECG changes or decreased wall motion was found. However, automated function imaging (AFI) showed decreased peak systolic strain at the apex and postsystolic shortening at both the apex and inferior wall, which was not found before the test. The provocation test revealed 99% stenosis in the right coronary artery #2 at a dose of 50 µg acetylcholine and 90% stenosis in the left coronary artery #8 at a dose of 100 µg. The patient was thus diagnosed as having VSA. The present case demonstrates the usefulness of AFI combined with hyperventilation and cold-pressor stress echocardiography as a screening examination for VSA.

BACKGROUND

Coronary spasm can cause vasospastic angina (VSA) as well as ischaemic heart disease, including unstable angina, acute myocardial infarction and sudden ischaemic death. Thus, a simple, safe and reliable diagnostic screening test for VSA should be established. Here, we present a case where hyperventilation and cold-pressor stress echocardiography combined with automated function imaging (AFI) successfully detected VSA at our outpatient facility.

CASE PRESENTATION

A 47-year-old male presented to the cardiology division in the St Marianna University School of Medicine Hospital with an approximately 1-month history of chest discomfort which appeared every 2–3 days and persisted for 10–20 min while sleeping or in the early morning. He had a medical history of untreated hyperlipidaemia and fatty liver, although no family history of sudden death or fainting.

INVESTIGATIONS

Results of haematological and serological examinations and chest radiograph were within normal limits. ECG showed a sinus rhythm of 75 beats per min (bpm) without any remarkable ST-T change. Echocardiography revealed preserved systolic and diastolic function with no regional wall motion abnormality, valvular dysfunction or pericardial effusion. The patient was suspected of having VSA, so hyperventilation and cold-pressor stress echocardiography was performed in the morning according to the method described by Shimizu *et al.*¹ Before the test the patient was informed about its usefulness, limitations and possible complications and written informed consent was obtained.

Echocardiography was carried out using a commercially available system (Vivid E9; General Electric-Vingmed, Milwaukee, Wisconsin, USA) with a 3.5 MHz transducer in the apical long axis, and 2-chamber and 4-chamber views. Images were digitally stored in the cine-loop format and transferred to commercially available software (EchoPac 7.0.0; GE Medical Systems, Horten, Norway) for off-line analysis. During the hyperventilation and cold-pressor stress test, the patient experienced no chest discomfort, remarkable ST-T change or arrhythmia. Heart rate and blood pressure were higher during the test (82 bpm and 164/90 mm Hg) than before the test (69 bpm and 134/72 mm Hg). Echocardiography showed preserved systolic function with no regional wall motion abnormalities. AFI showed decreased peak systolic strain at the apex and postsystolic shortening at both the apex and inferior wall, which was not found before the test (figure 1). Since the result of the hyperventilation and cold-pressor stress test was positive, cardiac catheterisation was subsequently performed for detailed evaluation. Coronary angiography showed normal coronary arteries. During the provocation test using acetylcholine, ECG showed no signs of ischaemia, and the patient had only slight chest discomfort. However, coronary vasospasm was induced in the right coronary artery #2 at a dose of 50 µg acetylcholine and in the left coronary artery #8 at a dose of 100 µg acetylcholine (figure 2).

TREATMENT

Treatment with benidipine (4 mg/day) and pravastatin (10 mg/day) was immediately initiated, which completely stopped the angina episodes.

Figure 1 Longitudinal strain curves and bull's eye plots. The bull's eye plots were obtained from the peak systolic strain (top) and postsystolic strain index (PSI; bottom) before (left) and immediately after hyperventilation and cold-pressor stress test (right), respectively. The decreased peak systolic longitudinal strain and increased PSI immediately after the test were observed in the inferoseptal and apical left ventricular segments that corresponded well with the affected arteries.

OUTCOME AND FOLLOW-UP

Follow-up hyperventilation and cold-pressor stress echocardiography was performed 2 months later in the patient under benidipine and pravastatin therapy. Neither decreased peak systolic strain nor postsystolic shortening was found; medical therapy prevented the recurrence of coronary spasm.

DISCUSSION

In general, coronary angiography with intracoronary injection of acetylcholine or ergonovine is used for identifying VSA. However, it is an invasive procedure which is expensive and requires hospitalisation. One study reported that the sensitivity of hyperventilation combined with cold-pressor stress ECG was 82% in VSA patients.¹ Distant *et al*² successfully detected coronary spasm using two-dimensional (2D) echocardiography before the onset of chest pain or ST segment elevation on ECG. Furthermore, Hirano *et al*³ reported that hyperventilation and cold-pressor stress echocardiography was useful for the diagnosis of VSA. However, the evaluation of left ventricular function abnormalities by qualitative estimation of wall thickening is somewhat subjective and requires considerable experience, as demonstrated by differences in sensitivity and specificity between novice and experienced operators. An acute reduction in regional myocardial blood flow causes local contractile dysfunction within a few seconds, which leads to regional deformation.⁴ Radial

thickening and circumferential/longitudinal shortening of ischaemic segments decrease during systole. Segmental relaxation is also impaired during ischaemia; physiological early diastolic thinning and lengthening are replaced by ongoing postsystolic thickening and shortening.⁴

Changes in early diastolic deformation are proposed as an early marker for regional ischaemia.⁵ 2D strain can evaluate longitudinal and circumferential abnormalities that precede a decrease in radial deformation in ischemia. Since subendocardial myocardial fibres are more susceptible to ischemia, longitudinal function might be altered earlier than radial function.⁶ This is why longitudinal strains are found to decrease in patients with mild coronary constriction and the administration of low-dose dobutamine.

AFI is a novel algorithm based on speckle-tracking imaging. Automated algorithm provides peak systolic longitudinal strain and postsystolic shortening for each left ventricular segment in a bull's eye plot. AFI provides the objective and accurate evaluation of ischemic wall motion abnormalities based on longitudinal strain. We thus chose AFI for the combination with hyperventilation and cold-pressor stress echocardiography.

In the present case, hyperventilation and cold-pressor stress echocardiography revealed the decreased longitudinal strain which appeared earlier than ECG changes, symptom and wall motion abnormalities, and AFI successfully detected VSA. Further data on the accuracy and usefulness of these non-invasive procedures will establish a new diagnostic method for identifying VSA at outpatient facilities.

Figure 2 Acetylcholine provocation test. Administration of 50 μ g acetylcholine resulted in vasospasm in the right coronary artery #2 and administration of 100 μ g acetylcholine resulted in vasospasm in the left coronary artery #8; the arrows indicate the vasospasm sites.

Learning points

- Longitudinal abnormalities precede a decrease in radial deformation in ischemia.
- AFI provides the objective and accurate evaluation of early ischemic wall motion abnormalities based on longitudinal strain.
- The combination of hyperventilation and cold-pressor stress echocardiography and AFI is useful for screening examination for VSA.

Competing interests None.

Patient consent Obtained.

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