

## Kvantitativna procjena stres ehokardiografije s fizičkim opterećenjem: primjena i ograničenja

### Quantitative assessment of exercise stress echocardiography: application and limits

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Stres ehokardiografija (SE) je široko primjenjivana metoda za procjenu koronarne bolesti srca, aktivnosti miokarda i bolesti srčanih zalistaka. Među raznim metodama SE, postizanje opterećenja srca fizičkom aktivnosti se pokazalo sigurnije od farmakološkog opterećenja.<sup>1</sup> Kvantitativna analiza gibanja stijenki za vrijeme SE može nadvladati manjkavosti vizualne procjene sistoličkog zadebljanja i gibanja miokarda, odnosno samo procjenu radijalne funkcije. Subendokardna vlakna koja podržavaju longitudinalnu funkciju osjetljivija su na ishemiju i popuštanje srca.<sup>2</sup> Nekoliko je metoda na raspolaganju za kvantitativnu procjenu funkcije lijeve klijetke koje se mogu izvoditi tijekom SE s fizičkim opterećenjem, a svaka ima neke nedostatke. Slikovni prikaz za analizu deformacija (SL) može biti izveden iz TDI (*tissue Doppler imaging*) ili temeljen na 2DS (*2-dimensional strain*). U svakoj metodi izvedenoj iz Dopplera, mjerene brzine su ovisne o kutu te apikalni segmenti ne mogu biti pouzdano opisani. Zbog gradijenta brzina od baze prema apeksu, potrebno je za svaki segment odrediti „cut-off“ vrijednost. Translacija i rotacija srca ograničava TDI.

Prikaz temeljen na 2DS je prikladniji za SE s fizičkim opterećenjem jer je neovisan o kutu i omogućava prikaz apikalnih segmenata i svih segmenata opskrbnog područja pojedine koronarne arterije. U našem radu prvo koristimo vizualnu procjenu WMSI (*wall-motion score index*), a potom i „single segment model“ temeljen na TDI s naknadnom analizom prije opterećenja i odmah po opterećenju (unutar minute) (slika 1). Vrijednosti br-

Stress echocardiography (SE) is widely used method for assessing coronary artery disease, myocardial viability and valvular heart disease. Among the various stress modalities exercise is safer than pharmacologic stress.<sup>1</sup> Quantitative wall motion analysis during SE may overcome deficiency of visual assessment of systolic thickening and myocardial motion i.e. estimating radial function only. Subendocardial fibers that support the longitudinal function are more sensitive to ischemia and heart failure.<sup>2</sup> There are different methods proposed for quantitative assessment of the left ventricular function feasible in exercise stress echocardiography and each has some drawbacks. Strain imaging techniques can be derived from the color-coded TDI (*tissue Doppler imaging*) or based on the 2DS (*2-dimensional strain*). In any Doppler-derived method, the velocities measured are angle-dependent, apical segments cannot be reliably depicted and, because of base-to-apex velocities gradient, there is a need for different segmental cut-off values. Cardiac translation and rotation limit the TDI.

The 2DS is more suitable for exercise SE for it is angle-independent and can be used in any projection. 2DS enables display of apical segments and all segments of the specific coronary artery territories. In our work, we first use visual estimation – WMSI (*wall-motion score index*) and then the single-segment model based on the TDI with off-line analysis before exercise and immediately upon peak exercise (within 1 minute) (Figure 1). Velocities, strain and strain-rate values are compared with cut-off values and

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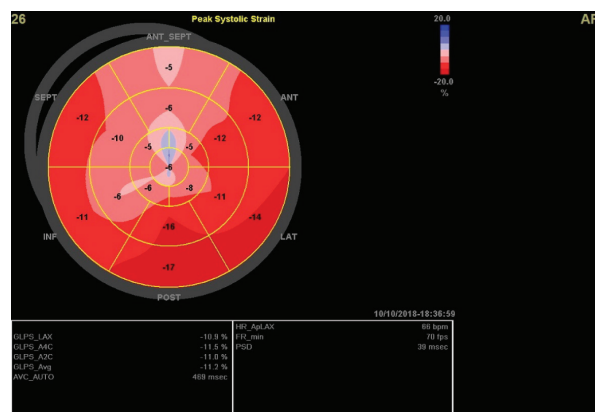
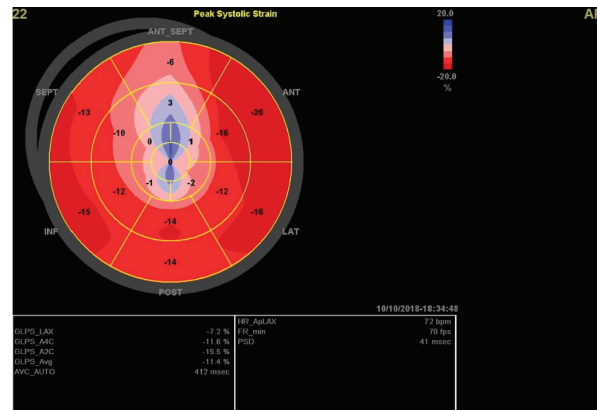


FIGURE 1. Tissue Doppler imaging analysis before and immediately after exercise: 20-year male patient with hypertrophic cardiomyopathy.



**FIGURE 2. Automated function imaging analysis before and immediately after exercise: 70-year female patient who has overcome myocardial infarction.**

zina, veličine i brzine deformacije uspoređuju se s cut-off vrijednostima i izražavaju kao delta >50%.<sup>3</sup> Dodatna analiza (AFI, *automated function imaging*) temeljena na 2DS, segmentalnih SL, PSS (*post systolic shortening*) i TTP (*time-to-peak*), kao i mjerenje E/E' omjera izvodi se prije i neposredno poslije opterećenja (slika 2). Prema našem iskustvu, ovaj kombinirani pristup pruža točniju procjenu ishemije i popuštanja srca. Izvodljivost 4D SE s fizičkim opterećenjem (i *full volume* i *multiplane*), prema našem dosadašnjem iskustvu, vrlo je niska zbog niske prostorne i vremenske rezolucije koja se pogoršava porastom frekvencije (FR 40 fps). Kombinirani pristup u kvantitativnoj analizi SE s fizičkim opterećenjem koji uključuje određivanje parametara i sistolne (WMSI, TDI, 2DS) i dijastolne funkcije (E/E') pruža točniju procjenu ishemije i/ili popuštanja miokarda.

expressed as delta >50% increase.<sup>3</sup> An additional analysis (AFI, *automated function imaging*) of segmental strain, PSS (*post systolic shortening*) and TTP (*time-to-peak*) longitudinal strain based on the 2DS as well as an estimation of the E/E' ratio are performed before and immediately upon peak exercise (Figure 2). This combined approach allows more accurate estimation of ischemia and heart failure. In our experience, feasibility of the 4D exercise SE, both full volume and multiplane mode, is very low because of low spatial and temporal resolutions which become worse at a faster heart rate (FR of 40 fps). The combined approach in quantitative assessment of exercise SE that includes determination of parameters of both systolic (WMSI, TDI, 2DS) and diastolic functions (E/E') provides a more accurate estimation of ischemia and/or heart failure.

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