P625

Impact of hemodialysis on a novel and noninvasive index for quantification of stroke work obtained by left ventricular pressure-volume loop area using speckle tracking echocardiography

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Background: Left ventricular (LV) pressure-strain and pressure-volume (P-V) loop area reflect global myocardial work (MW) and stroke work (SW), but clinical use of these indexes is limited by the need of invasive pressure measurement. A noninvasive method to obtain LV pressure-strain loop area was recently introduced to examine MW by speckle tracking echocardiography (STE).

Purpose: We sought to evaluate the impact of preload change on MW and SW obtained using this novel method and to examine the utility to assess LV contractile performance by the SW and end-diastolic volume (EDV) relation (SW-VED) in patient with hemodialysis (HD).

Methods: LV pressure in a cardiac cycle was estimated using systolic blood pressure (SBP), LV minimum diastolic pressure (mDP) and end-diastolic pressure (EDP) in 20 HD patients (age 67±9)and 25 controls (age 67±9) by utilizing the profile of an empiric, normalized reference curve adjusted according to the duration of LV isovolumic and ejection phases as defined by timing of aortic and mitral valve events by echocardiography. Pulmonary capillary wedge pressure (ePCWP) is estimated as 10.8 – 12.4 $\times$ Log (left atrial active emptying function/minimum volume): KT index as previously reported. LVEDP were estimated as 12.3 – 10.1 $\times$ KT index. We examined the relation between LV pressure decline (Tau) and mDP by catheterization in 126 patients. Tau is estimated as isovolumic relaxation time/(ln 0.9 $\times$ systolic BP − ln ePCWP) as previously reported. SW was obtained by P-V loop area using the combination of pressure (SBP, mDP and EDP) and LV volume by 3D-STE. Echo parameters and BP were measured before and after HD and before and after leg up in controls.

Results: The mDP obtained by catheterization had a good correlation with Tau (Tau = 33.7 + 2.06 $\times$ mDP, r=0.70, $p<0.01$). LVEF by 3D-STE was increased in controls after leg up (59±5 to 62±4%) associated with increased LVEDV (85±25 to 91±26ml), whereas there was no difference in LVEF before and after HD (61±9 vs 61±10%) instead of decreased EDV after HD (101±23 to 92±24ml). SBP and PCWP in HD was decreased after HD (SBP: 149±25 to 140±15, PCWP: 9.8±4.3 to 8.5±3.6mmHg). MW and SW were increased after leg up in controls (1706±443 to 1972±461mmHg% and 4072±1938 to 5044±1958mmHgml) and those were decreased after HD (1964±441 to 1794±756mmHg% and 5475±1335 to 4722±1949mmHgml). LV SW-VEDin HD without LV dilation (EDVI$<$70ml/m^2, n=12) was decreased compared to controls (143±115 vs 241±152) and that in HD with LV dilation was further decreased compared to HD without dilation.

Conclusion: LVSW noninvasively obtained by P-V loop area was increased in controls associated with increased preload and decreased in HD with decreased preload and SW-VED was deceased in HD. This novel and noninvasive method may be of potential utility to assess LV contractility and have a clinical interest and value to assess LV function.