Evaluation of cardiac function in cancer patients by wall motion kinetics using cine cardiac MRI: A feasability study

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Target audience

Cardiac radiologists, cardiologists, medical oncologists and muscle physiologists.

Purpose

Skeletal muscle dysfunction at the molecular, cellular, whole-muscle and whole-body level in cancer patients with or without cachexia has recently been demonstrated, including reduction in single fiber isometric tension in myosin heavy chain (MHC) IIA fibers, reduction in myosin-actin cross-bridge kinetics in MHC I fibers, and reduced mitochondrial density.[1] Cardiac muscle function, particularly diastolic function, may be similarly affected. Comprehensive evaluation of cardiac systolic and diastolic function can be performed using cardiac MRI, however, assessment of diastolic function using two dimensional velocity encoded MRI (VEC-MRI) derived from echocardiography techniques assessing left ventricular inflow, pulmonary vein flow and left ventricular myocardial movement (equivalent to tissue Doppler), while similar in sensitivity and specific to echocardiography, require time-consuming post processing, analysis and precise imaging planes tangential to flow.[2] The goal of this study was to asses diastolic function using left ventricular wall motion relaxation kinetics derived from multi-phase, balanced steady state free precession cine MRI using a semi-automated technique compared to velocity encoded MR flow analysis.

Methods

5 patients with cancer (lung, gastric, pancreatic, larynx) and no underlying cardiac disease underwent cardiac MRI (3.0 Tesla Philips Achieva) using a 6-channel cardiac coil with parallel imaging. VEC-MRI flow measurements (8 mm slice thickness, TR 4.6 ms, TE 2.6 ms, flip angle 10, number of phases 121) were obtained at the base of the left ventricle near the mitral valve (TI 150 ms), the orifice of the right superior pulmonary vein (TI 100 ms), and the mid portion of the left ventricle (TI 30 ms). Balanced steady state free precession cine MRI (B-TFE, 8 mm slice thickness, TR 2.5, TE 1.3, number of phases 188, flip angle 35) was performed in the short axis plane extending from the cardiac apex through the atria. 30 cardiac phases per slice were obtained. VEC-MRI and cine MRI were analyzed on a Philips Extended Workspace by a cardiothoracic radiologist with 8 years of experience (GEG). Left ventricular inflow, pulmonary vein flow, and left ventricular myocardial movement was analyzed from VEC-MRI data. Volumetric analysis was performed using Simpsons method with semi-automated contour detection of all 30 cardiac phases at each continuous slice from apex to base with manual correction. Left ventricular ejection fraction, mass, systolic ejection rate, first filling peak rate (passive relaxation), second filling peak rate (during atrial contraction), and percentage of cardiac cycle in diastasis (slope <0.01) were calculated from volume versus time curves and compared to flow data for evidence of diastolic dysfunction. First filling peak rate, systolic ejection rate and percentage of cardiac cycle in diastasis were compared in subjects with and without diastolic dysfunction using Student's T-test.

Results

There were 2 men and 3 women with a mean age of 63.2 years (± 12.9) one of whom was clinically cachectic (unintentional weight loss ≥ 5% in last 6 months).[1] All had normal systolic function (mean ejection fraction 61.9% ± 7.0) and left ventricular mass (mean 69.7 grams ± 23.9). 4 of 5 subjects had evidence of Grade I (mild) diastolic dysfunction from VEC-MRI parameters (E/A < 0.08, septal e' < 8 cm/s, lateral e' < 10 cm/s, and DT < 240 msec) and one had no evidence of diastolic dysfunction. Mean diastolic first filling peak rate was 0.20 mL/ms ± 0.08, mean second filling peak rate was 0.29 mL/ms ± 0.08, and percentage of cardiac cycle in diastasis was 11.7 % (± 10.3). Mean systolic peak ejection rate was 0.36 mL/ms (± 0.22). Mean diastolic first filling peak rate was 0.17 mL/ms (± 0.04) in patients with diastolic dysfunction compared to 0.32 mL/ms in the one normal subject (p = 0.03). Mean percentage of cardiac cycle in diastasis was 8.6% (± 9.0) in patients with diastolic dysfunction compared to 23.8% in the one normal subject (p = 0.11). Mean systolic ejection rate was 0.27 mL/ms (±0.06) compared to 0.75 mL/ms in the normal subject (p = 0.002).
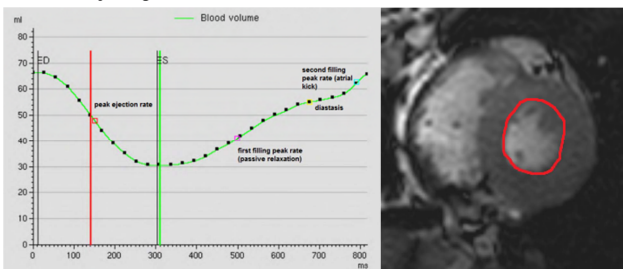
Left ventricular volume/time curve with peak velocity rates in systole and diastole
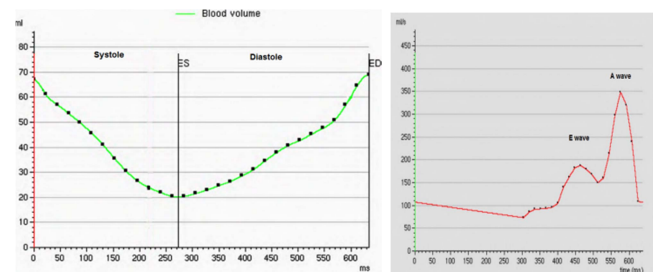
Slow upslope of first filling rate and E/A reversal from VEC-MRI

Discussion

In this cohort of patients with cancer and evidence of skeletal muscle dysfunction, diastolic dysfunction was common (80%). Decline in first filling peak rate (<0.25 mL/ms) predicted diastolic dysfunction compared to VEC-MRI with statistical significance, and there was a trend toward identification of diastolic dysfunction with decline in duration of diastasis. Differences in the peak systolic ejection rate between subjects with and without evidence of diastolic dysfunction also suggest an association with cardiac muscle dysfunction despite preservation of global left ventricular systolic function (EF). Analysis of semi-automated cine MRI was simpler and less time consuming than VEC-MRI.

Conclusion

Use of left ventricular wall motion kinetics using semi-automated, multi-phase cine cardiac MRI is effective at identifying patients with early diastolic dysfunction compared to VEC-MRI, and may be effective in detecting subtle abnormalities in systolic function.

References

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