

Left ventricular function assessment in a single breath-hold using a 2D FIESTA with Steady-State preparation

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Purpose:

To develop and validate a method to assess left ventricular function in a single breath-hold.

Introduction:

Cardiac Cine 2D SSFP imaging is the gold standard to assess cardiac dimension and function [1, 2]. Limitation of the technique is the need for patients to complete several breath-holds (eight to ten) to cover the whole heart. The aim of this study was to evaluate a single breath-hold method, using a 2D FIESTA-SP sequence (gated FIESTA with Steady State preparation) [3] with scan time efficiency to nearly 100%, to assess left ventricular function.

Material and methods:

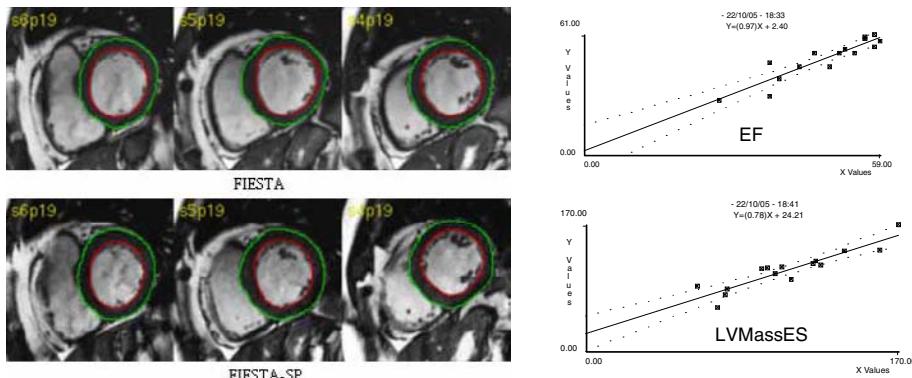
All images were obtained with a 1.5T Signa TwinSpeed (GE Healthcare, Waukesha, WI, USA) with 40 mT/m gradients. A mixed population of volunteers (20%) and patients (80%) ($n = 15$ – mean age 35 years, min 28 – max 59 years) with cardiac disease underwent randomly 2D FIESTA-SP and 2D FIESTA acquisitions, 2D FIESTA being used as the gold standard. In FIESTA-SP, steady state for each slice was achieved using a linear flip angle series of excitations during the 1st cardiac phase of the 1st heartbeat for each slice [3, 4], while in FIESTA, 2 dummy heartbeats are needed. Both acquisitions were performed with identical temporal resolution. For complete coverage of the left ventricle, 8 to 10 short-axis sections (8-mm thick with 2-mm gaps) were acquired. Acquisition time of the FIESTA sequence, for each section, was 21 heartbeats or around 8 minutes to acquire all slices. Acquisition parameters were: TR/TE of 4.2/1.4 ms, flip angle of 45°, 1 signal acquired, matrix of 224 x 224, field of view of 380-440 x 380-440 mm², 12 views per segment (VPS), and temporal resolution of 50 msec. The same section positions were then imaged with the FIESTA-SP sequence. Acquisition time for each section was 3 heartbeats; total scan time for all sections was 24 to 30 heartbeats or 30 seconds maximum. The FIESTA-SP sequence was performed with TR/TE of 3.0/1.3, flip angle of 45°, 0.5 signal acquired, matrix of 160 x 262, field of view of 380-440 x 380-440 mm², 18 VPS, thus achieving a temporal resolution of 54 msec. A parallel imaging factor of 2,5 was used.

Image analysis:

Image quality (absence of flow or motion artifact, sharpness of subendocardial contours) was assessed for each sequence. A quality grading (from 1, non-diagnostic to 5, excellent) was derived from this analysis. Cardiac function study was performed for each short-axis left ventricle image using Mass software, Medis, Leyden, The Netherlands. Two independent viewers manually defined end-diastolic and end-systolic endocardial and epicardial borders, ejection fraction (EF), stroke volume (SV), end-diastolic (LVEDV) and end-systolic (LVESV) volume, diastolic (LVMassED) and systolic (LVMassES) mass. Data from both sequences were compared using a two-way ANOVA test. One reader additionally performed two successive measurement sessions; intra and inter-reader reproducibility were calculated.

Results:

Qualitatively, both sequences displayed similar image quality, with an average grading of 4.5 ± 0.65 for FIESTA vs 4.57 ± 0.51 for FIESTA-SP. There were more artifacts with FIESTA than for FIESTA-SP (7 and 5 examinations, respectively), but all were mild and hence, none provided non-diagnostic data. The sharpness of endocardial contours was judged similar for both sequences. Quantitatively, intra-technique (FIESTA and FIESTA-SP) concordance analysis between readers was validated on the EF value (P value < 0.0001). Measure agreements was obtained between the 2 imaging methods on all data derived from endo and epicardial borders of the left ventricle, with a P value < 0.0001 , which is considered extremely significant.



Conclusion:

FIESTA-SP increases the scan time efficiency to nearly 100% (vs 50% for FIESTA, using the same parameters of acquisition) by eliminating dummy heartbeats. With almost equal image quality, the single breath-hold FIESTA-SP protocol leads to an excellent evaluation of the left ventricular function. Measurements of EF, SV, LVEDV, LVESV, LVMassED and LVMassES are comparable with those derived from a series of separate breath-hold single-section conventional FIESTA acquisitions. As repeated breath holding is time consuming and exhausting for the patient and can also increase the likelihood of slice misregistration, which may impact quantitative measurements, the FIESTA-SP pulse sequence proves to be an accurate technique for evaluating cardiac function in a single breath hold.

References:

- [1] Longmore DB et al. Lancet. 1985 Jun 15;1(8442):1360-2.
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