Quantification of Left Bundle Branch Block on Left Ventricular Regional Wall Motion Using Six-Segment Center Point Trajectory Mapping

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Introduction

Left Bundle Branch Block (LBBB) is a common cardiac electrical conduction abnormality. When the impulse is delayed or fails along the conduction fibers, the efficiency of the heart to complete its stepwise synchronous depolarization and repolarization becomes compromised and the heart cannot beat efficiently due to the dyssynchrony. It is possible to quantify the mechanical severity of LBBB using cardiac MR for patient care planning. In this context, we propose a six-segment center point trajectory (CPT) approach on existing cardiac cine images, without any additional sequence or sophisticated data analysis, for LBBB quantification.

Methods

Cardiac MRI was performed on nine subjects: 5 normal volunteers (3 male, 47±5 y/o, EF 62%±3%) and 4 patients with known LBBB (3 male, 45±17 y/o, EF 53%±2%) but negative myocardial delayed enhancement (MDE), who were in a retrospective study protocol. Cardiac cine sequences were collected using a 2D SSFP sequence and an 8-channel GE cardiac coil on GE 1.5T Signa HD (Waukesha, WI). The proposed six-segment CPT utilized standard short axis cine SSFP images (TR/TE 3.6/1.6ms; 224 x 224 matrix; 8 mm slice thickness; 1.25 x 1.25mm, 1 NEX; VPS 20; 20 phases). The whole heart CPT and the six-segment CPT technique were both implemented on all cases. The whole heart CPT detects the center point of the LV blood pool over time; the six-segment CPT divided the LV blood pool into six segments per slice based on AHA 17 segments model [1] and then calculate the center point trajectory in each segment. The motion of the center point within each segment can be decomposed to radial and circumferential directions. The maximal radial center point motion can be used as a quantitative criterion to evaluate the mechanical impact of LBBB. A paired t-test was performed to compare the two septal segments in healthy volunteers to LBBB patients.

Results

Fig. 1 shows an example of whole heart CPT (red square - systole; blue circle - diastole) and six-segment CPT (six curves shows six center point trajectories in corresponding segments) from a normal volunteer. As expected, the whole heart center point trajectory had limited motion of 2.2 mm and six segment trajectories were evenly balanced in all segments. Fig. 2 shows an example of patient results. In this case, the whole heart CPT demonstrates a maximal displacement of 7.0mm, but it shows wide angle of trajectory and does not specify the location of the abnormal wall motion area. In comparison, the six-segment trajectory located the abnormal area by showing smaller amplitudes (two black arrows) due to dyssynchronized motion. The maximal radial motion for each segment trajectory was summarized in Table 1 for all nine subjects. A scatter plot for this metric on septal regions was shown in Fig. 3. Comparisons of the maximal radial motion in the anterio-septal and infero-septal segments between normal and LBB subjects were statistically significant (p=0.0063 and 0.0075 respectively).

Conclusions

This study demonstrates the feasibility of six-segment CPT in detecting abnormal anteroseptal and inferoseptal wall motion in LBBB patients. Quantitative evaluations showed significant difference between normal and LBBB patients. Furthermore, this new technique can be implemented retrospectively on existing cardiac cine data and does not require any additional sequence or acquisition.

References [1] Manuel D. Cerqueira, et al, Circulation 2002;105:539-542

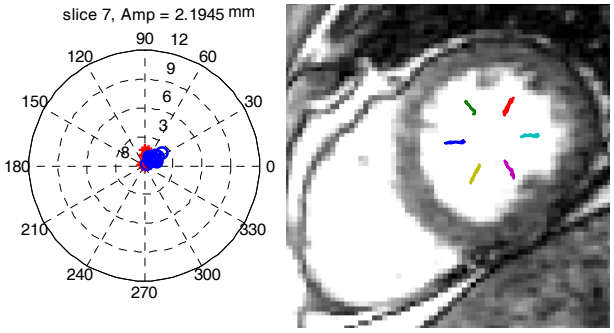

Figure 1. A 38-year-old male normal volunteer (EF 58%) shows whole heart CPT (left, red square - systole; blue circle - diastole) and six segment CPT (right).

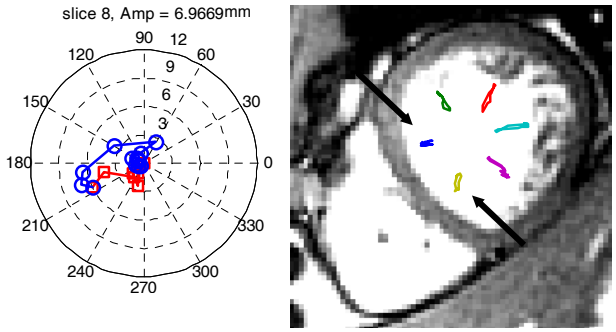

Figure 2. A 22-year-old male LBBB patient (EF 55%) shows with whole heart CPT (left, red square - systole; blue circle - diastole) and six-segment CPT (right).

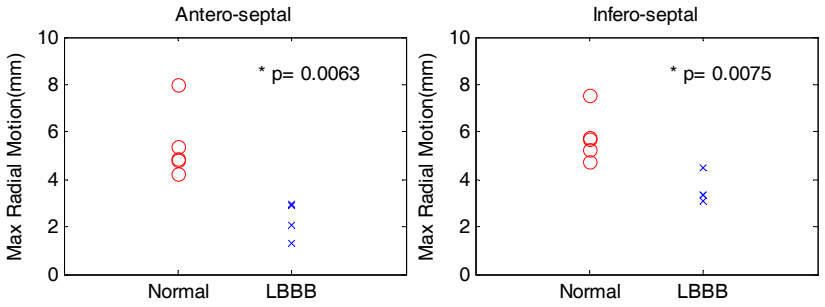

Figure 3 : Comparison of the maximal radial motion of normal and LBBB subjects at septum.

Table 1. Maximal radial motions of normal and LBBB subjects.

MaxRadial Motion (mm)	Antero-septal	Anterior	Lateral	Posterior	Inferior	Infero-septal
Normal 1	4.81	5.20	6.93	8.71	7.15	5.67
Normal 2	4.85	7.50	7.71	6.33	6.00	4.76
Normal 3	7.97	6.32	6.78	9.65	9.66	7.54
Normal 4	5.36	4.23	4.70	4.82	5.45	5.76
Normal 5	4.24	5.53	7.50	7.42	6.52	5.28
LBBB 1	*1.30*	4.88	8.88	10.16	6.82	*3.32*
LBBB 2	*2.95*	5.65	8.02	9.44	8.17	*4.51*
LBBB 3	*2.89*	5.04	5.44	5.55	4.41	*3.06*
LBBB 4	*2.04*	3.65	6.57	7.40	6.24	*3.37*