A navigator gated free-breathing FSE for black blood cardiac imaging

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Purpose: To develop a navigator echo gated FSE with double/triple IR sequence for free-breathing black-blood cardiac imaging.

Materials and Methods: The respiratory navigator echo was integrated with double/triple IR FSE sequence (NAV-FSE). The navigator bar was placed on the doom of diaphragm and a prospective gating scheme, phase ordered with automatic window selection (PAWS), was applied. For any two spatially continued section (1mm each), the center and the peripheral part of the k-space were allocated. The most frequent positions will complete the data sampling earlier and then move to the other slices until all the slices were completed. A breath-hold product sequence (BH-FSE) was taken as control, keeping the other parameters the same, FOV=36*36cm, matrix 256*192, 8mm slice thickness/ 2mm spacing. For NAV-FSE, different ETL, 8,16 and 24, were tested but on BH-FSE only ETL=16 and 24 were tested. On ImageJ, the width of edge detection was meatured and the 1/w was named as the sharpness. The navigator efficiency (calculated heartbeats/required heartbeats) was evaluated and image quality was compared.

Results: 16 volunteers completed all NAV-FSE acquisitions while 4 BH-FSE acquisitions (ETL=16) failed because of poor breath holding. The efficiencies of NAV-FSE was (42.95±11.5)%, (56.14±11.4)%, and (55.25±14.7)% when ETL was 24, 16 and 8, respectively. As in the Table, when ETL=16, NAV-FSE has the best sharpness when compared to NAV-FSE with ETL=24 and BH-FSE, showing statistical difference ($P<0.05$). There is no statistically improvement when ETL decreased from 16 to 8.

Conclusion The navigator echo could integrated with double/triple IR FSE to acquired the black-blood image of the heart in free-breathing mode, avoiding the restriction of the breath hold and it provided opportunity to optimize the parameters to improve the image quality.

Table: Comparison between NAV-FSE and BH-FSE

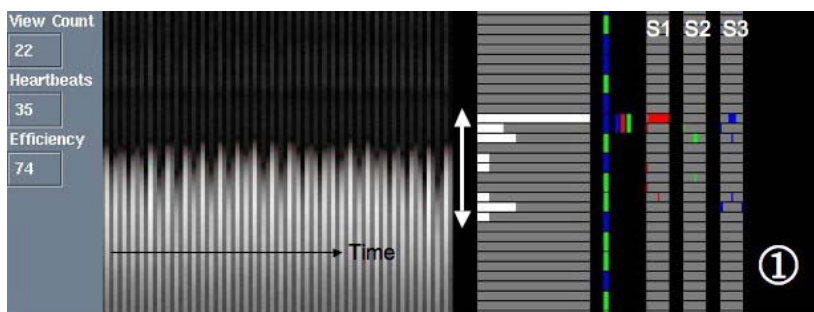| Parameters	NAV-FSE			BH-FSE	
ETL	8	16	24	16	24
Calculated heartbeats	24	12	8	12	8
Required heartbeats	43.4±12.4	21.4±4.95	18.6±4.56	-	-
Edge sharpness	0.41±0.03	0.43±0.02	0.36±0.02	0.36±0.03	0.35±0.02

Figure 1: Diagram of the PAWS navigator echo triggered sampling. *View count* is the calculated remaining RR intervals for the acquisition. *Heartbeat* is the RR intervals that had been used. *Efficiency* is the ratio of effective RR intervals to used RR intervals. Different slices were acquired on different diaphragm positions (different colors S1~3).
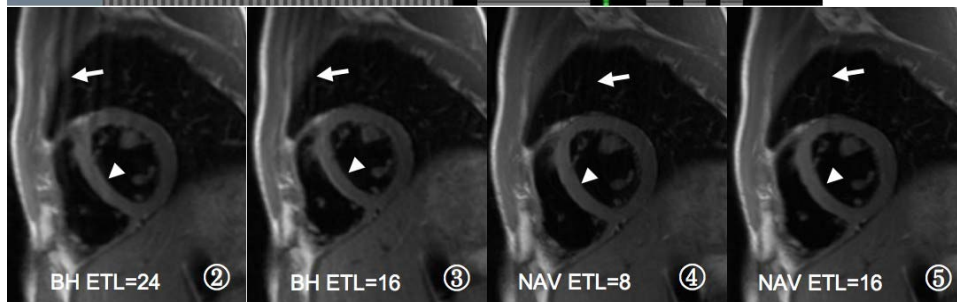

Figure 2~5: NAV-FSE and BH-FSE using different ETL. The thoracic wall artifact is worse on BH-FSE than on NAV-FSE(↑). The edge sharpness when ETL=8 is better than when ETL=24 (▲) and the fine structure can be identified when ETL=8.