Are we Reconstructing the Best Images using navigator-gated 3D coronary MRA? Multiple-Image reconstruction using CLAWS

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Introduction : Navigator acceptance techniques typically require a user-defined acceptance window to be set prior to the scan. This is usually placed around end-expiration. However, in subjects with non-regular breathing profiles, this may not always be possible as there is no stable end-expiratory position (Figure 1).

Figure 1

In situations such as this, it is not clear where the window should be placed. Whilst velocities near end-expiration tend to be lower than those in inspiration, it is not possible to select a uniquely end-expiratory window in this case. A 5mm acceptance window can be selected but will consist of both expiratory and inspiratory positions which may impact on the image quality. An alternative would be to acquire only data acquired in an expiratory position. However, this results in an unpredictable total range of motion and it is not possible to prospectively decide which diaphragm positions are in end-expiration.

The CLAWS (Jhooti et al 2005) technique enables automatic selection of the most efficient static acceptance window for any respiratory profile. However, as the position of this window is determined by the most common respiratory positions, it is possible for a window to be selected which is towards inspiration. With erratic respiratory profiles as that shown in Figure 1, it is impossible to predict which respiratory positions to select for image reconstruction. A modified version of the CLAWS technique is presented which automatically presents the operator with a choice of 3 images: the most efficient 5mm static window, an end-expiratory dataset and an end-inspiratory dataset.

Methods : CLAWS requires no acceptance window to be set as it assumes all possible windows are required. The data acquisition algorithm is adapted to the respiratory profile to enable the quickest possible image to be reconstructed (p = ns). The CLAWS technique was modified to enable multiple images to be reconstructed. The scan terminates as normal with an image reconstructed from the most efficient 5mm window. As the entire respiratory profile has been stored, it is possible to retrospectively assign the following information to each datablock which has been acquired: the relative displacement from its end-expiratory position and its end-inspiratory position. A dataset is reconstructed with the datablocks closest to end-expiration in each case. Another similar dataset is reconstructed for end-inspiration.

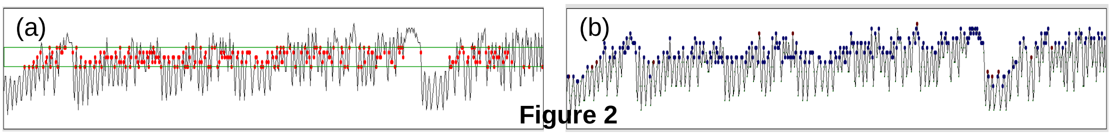


Figure 2

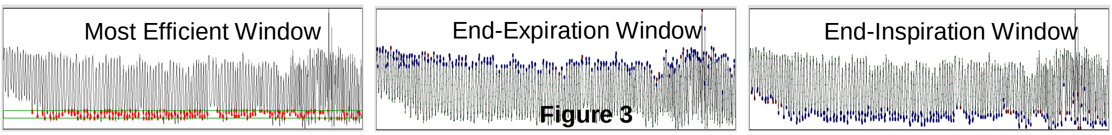


Figure 3

In Figure 2, the respiratory positions used for the most efficient window (a) are displayed along with those for the end-expiratory dataset (b). Figure 3 shows an example where the most efficient window was towards end-inspiration. The end-inspiratory window still differs however as it selects datablocks whose relative displacement for end-inspiration is least regardless of its absolute position.

Results & Conclusion: Figure 4 shows 3 images from a normal subject dataset: (a) most efficient window, (b) end-expiratory window, (c) end-inspiratory window. The respiratory profile spans the 3 images. As would be expected, the end-inspiratory image is of the lowest quality.

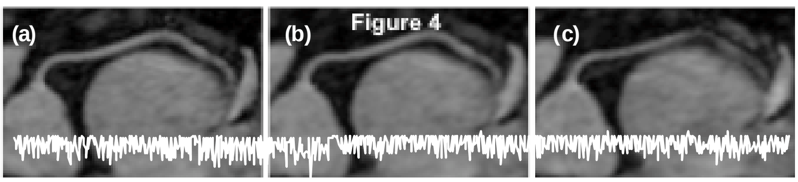


Figure 4

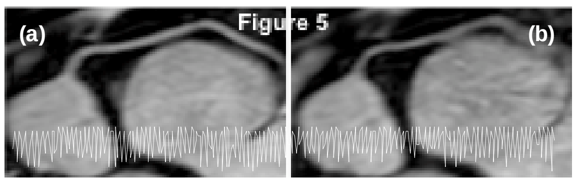
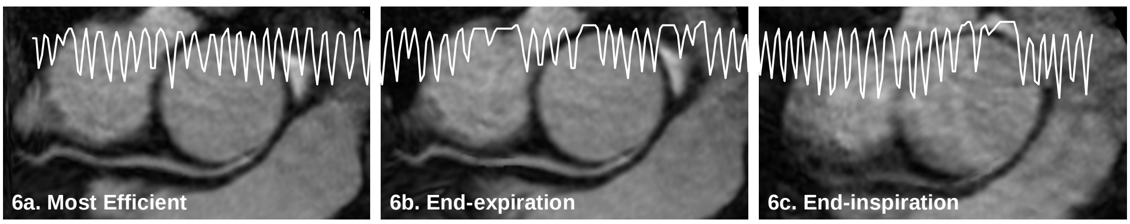


Figure 5

However, it is difficult to predict which image will be the best, even with the information available as to the respiratory profile and which positions are used in the final dataset. Typically, the best image is the most efficient static window or the end-expiratory image and these two images often use almost the same data. However, Figure 5 shows a case where the end-inspiratory image (a) was better than the most frequent window (b) for the same patient. Given the respiratory trace, it would have been natural to assume that the most efficient window, which was acquired in end-expiration, would have provided the best image. A patient example, with similar outcomes to Figure 4, is shown in Figure 6: the end-inspiratory image (c) is of significantly inferior image quality when compared to the most efficient image (a) and the end-expiratory image (b).



6a. Most Efficient 6b. End-expiration 6c. End-inspiration

In conclusion, CLAWS acquires each dataset in the quickest time possible (p = ns) and enables reconstructions of end-expiratory and end-inspiratory images with no additional scan time required than for a single image. All window selection is automatic and the operator may also abort a scan at any time after the first pass and receive the three images. As it is not possible to predict which static window placement will provide the best image quality or whether it is preferable to acquire expiratory or inspiratory positions, regardless of final window size, a technique which provides all options with no loss of scan time is preferable and desirable. Further, as all the data is available, it is possible to reconstruct an image from any combination of the data acquired.