

## Wavelet denoising of first-pass perfusion: impact on visual assessment.

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### Introduction

Clinical first-pass myocardial perfusion presents stringent imaging requirements which limits contrast-to-noise ratio (CNR) and diagnostic confidence. An impaired perfusion reserve, especially in hypertrophied regions, has been found in hypertrophic cardiomyopathy (HCM) patients [1]. Wavelet denoising is a common method of reducing noise in an image without sacrificing spatial-resolution [2]; many different approaches have been proposed to increase SNR in MR images based on this technique [3]. It has also been shown that myocardial perfusion quantification accuracy in a pixel-by-pixel basis may improve with wavelet denoising [4].

### Purpose

We examined the impact of wavelet denoising on the diagnostic confidence, during a visual assessment of first-pass myocardial perfusion in a cohort of HCM patients.

### Methods

12 patients diagnosed with HCM were scanned with a multi-slice saturation-recovery hybrid echo-planar-imaging sequence with four-echoes and a centre-out interleave phase-order, on a 1.5T scanner (Siemens Avanto). 11 patients were diagnosed with widespread inducible perfusion defects. Imaging protocol: TR/TE 5.6/1.12 ms, flip-angle 28 deg; voxel-size 2.3×2.3×8 mm; bandwidth 1735 Hz/pixel; TSENSE (R=2); TI 100 ms; Gd-based contrast-agent 0.1mmol/kg at 3.5ml/s. The images were post-processed with a non-rigid motion-correction algorithm.

The perfusion magnitude-images were denoised with a wavelet-threshold penalisation method [5]. This method is fully automatic apart from a penalty term that once established was kept constant across all patients.

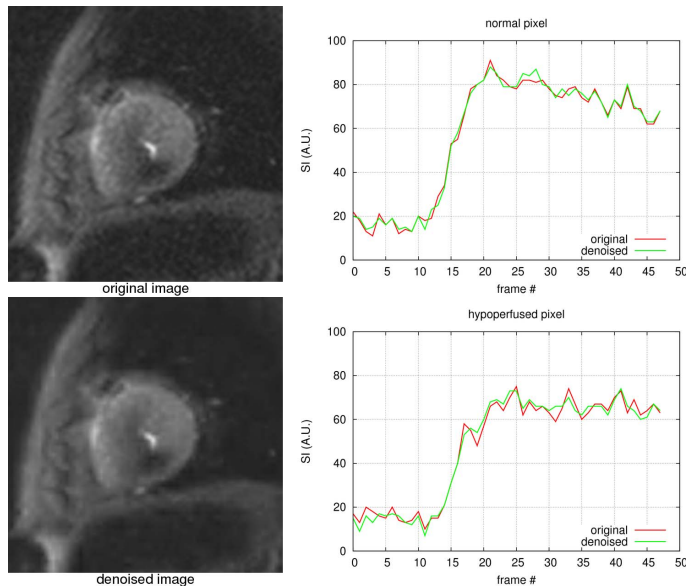
The original images, and the corresponding denoised ones were randomly shuffled and scored by two experienced blinded observers. Each slice was divided into four myocardial-segments, and a confidence score for each segment was assigned (0 non-diagnostic, 1 low, 2 moderate, 3 high). An average myocardial CNR increase was also recorded for each patient. Post-hoc analysis was made with a paired Wilcoxon signed rank test.

### Results/Discussion

The average myocardial CNR (contrast before and at peak contrast-enhancement) increased by a factor of 1.9 (SD 0.1), essentially due to a reduction of the noise (average relative change in contrast 0.1% (SD 0.3%)) (Figure 1).

The average difference in the diagnostic confidence was negative for both observers, i.e. worse after denoising, although the score difference is only significant for observer A (Table 1).

The obtained results might be explained, at least partially, by the human eye being more sensitive at certain temporal frequencies [6], and also by an “eye-ball” temporal smoothing during a dynamic visual assessment. These effects reduce the impact of noise during a visual analysis, possibly making it preferable to an increase in blurring. Wavelet denoising can still be used *a posteriori* for quantification analysis, in the image or in the SI curve data.



### Conclusion

Initial results on assessing the effects of wavelet denoising on the diagnostic confidence, during a visual assessment on a first-pass perfusion series, seem to be detrimental.

### References:

- [1] Petersen, et al., Circulation, 115:2418, 2007.
- [2] Donoho, IEEE TIT, 41:613, 1995.
- [3] Weaver, et al., MRM, 21:288, 1991.
- [4] Goldstein, et al., MRM, 56:439, 2006.
- [5] Birge, et al., Festschrift for Lucien Le Cam, Springer, 1997.
- [6] Watson, et al., Nature, 302:419, 1983.

**Figure 1:** An example of a perfusion image before (top left) and after denoising (bottom left). The SI curves on the right show the signal intensity throughout the 48 frame series for two particular pixels: a pixel in a normal myocardial segment (lateral wall represented by the blue square in the original image) (top right plot); and a pixel in a hypoperfused segment (inferior wall represented by the yellow square in the original image) (bottom right plot).

Table 1:

|            | Mean difference | z (Wilcoxon test) | p (Wilcoxon test) |
|------------|-----------------|-------------------|-------------------|
| Observer A | -0.11           | -2.75             | 0.006             |
| Observer B | -0.08           | -1.43             | 0.153             |