Whole-body Dixon for skeletal muscle fat fraction quantification in neuromuscular disorders

Benjamin Marty[1], Pierre-Yves Baudin[1], Benjamin Robert[2], Alexey Shukelovich[1], Robert-Yves Carlier[3], Noura Azzabou[1], and Pierre G Carlier[1]
[1]AIM-CEA Institut de Myologie, Laboratoire RMN, Paris, France, [2]Siemens Healthcare, Saint-Denis, France, [3]AP-HP Hôpital Universitaire Raymond-Poincaré, Garches, France

Target audience: Clinicians interested in fat infiltration quantification in skeletal muscle.

Introduction

Fatty infiltration of muscles is a marker of disease progression in many neuromuscular disorders, in particular muscular dystrophies. Muscle MRI is capable of revealing patterns of muscles involvement that are disease specific and facilitates the diagnostic workup of patients. Although routine T1-weighted (T1w) imaging can give an indication of the presence or absence of muscular fat infiltration, it is difficult to extract quantitative data from these images. Indeed, even if various semi-quantitative visual assessment scales are available to describe the fatty infiltration in the muscle from T1w images, recent studies showed that they cannot be sensitive enough to detect small changes, especially in intermediate fat fraction ranges [1,2]. 3-points Dixon method [3] uses the phase difference between water and fat to separate the two components. Unlike T1w images, it can give a quantitative measure of both water and fat fraction. Generally, whole-body exams consist in the acquisition of the T1w sequence, followed by Dixon acquisitions on targeted regions to quantitatively assess fat infiltration [4]. The goal of our study was to demonstrate that the use of a well calibrated sequence allows replacing whole-body T1w imaging by a whole-body Dixon imaging.

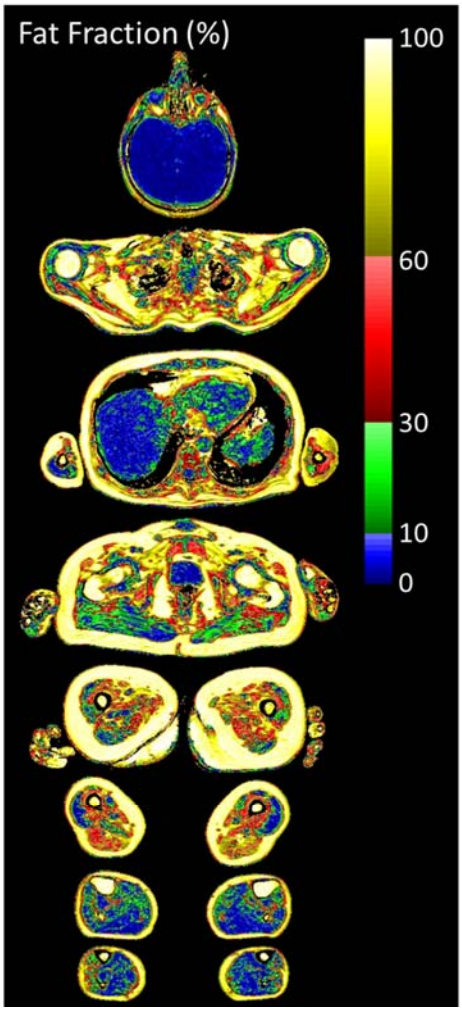

Figure 1: Whole-body fat fraction map

Materials & Methods

One patient exhibiting severe fat infiltration was scanned on a 3T whole-body scanner (Tim Trio, Siemens Healthcare). Whole-body T1w images were acquired with a 6-step 2D turbo spin echo sequence (TE/TR = 9.8/507 ms, in plane resolution = 1.1x1.1mm^2, slice thickness = 6mm, slice gap = 9.6mm) in a total acquisition time of 5min40s. Whole-body Dixon acquisition consisted in a 5-steps 3D volumetric interpolated brain examination sequence (VIBE) with 3 echo times (TE1/TE2/TE3/TR = 2.75/3.95/7.55/10ms, spatial resolution = 1x1x5mm^3) for a total acquisition time of 14min5s. Quantitative fat fraction maps were derived from the VIBE sequence using a standard 3-points Dixon reconstruction method. A customed lookup table was embedded in the DICOM file to provide a clear lecture of fat fraction maps corresponding to the Mercuri's scale [5] (blue gradient: normal muscle <10% fatty infiltration, green gradient: mild fatty infiltration <30%, red gradient: moderate fatty infiltrations between 30-60%, yellow gradient: severe fatty infiltrations >60%).

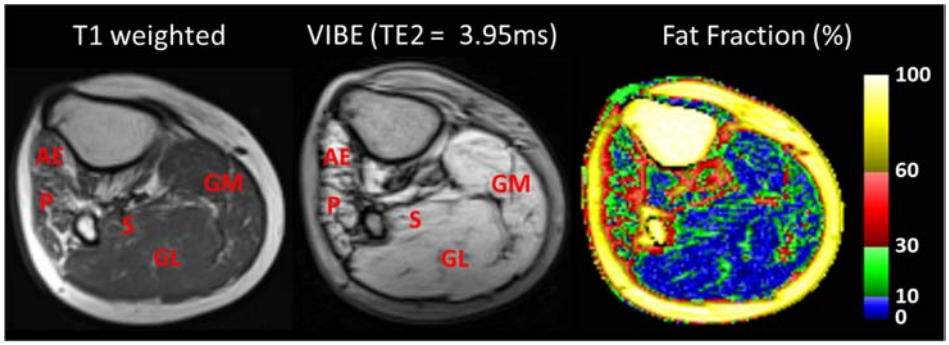

Figure 2: T1 weighted, second echo of VIBE sequence and fat fraction map of the patient's calf (GM: medial head of gastrocnemius, GL: lateral head of the gastrocnemius, S: soleus muscle, P: peroneus muscle, AE: anterior extensor muscles)

Results

Figure 1 shows eight slices of the whole-body fat fraction map derived from the 3-echoes VIBE sequence. At the first glance, the radiologist can estimate the location and severity of fat infiltration in the entire musculature of the patient. In figure 2, T1 weighted image of the calf is compared to the colored fat fraction and shows that peroneus muscles (P) and anterior extensor muscles (AE) are the most infiltrated in the lower leg.

Discussion & Conclusion

Our results show that the acquisition of a high resolution whole-body Dixon imaging is possible in less than 15 minutes using our optimized 3-echos VIBE sequence. This provides quantitative data that are more suitable than T1w images for longitudinal natural history studies, or therapeutic clinical trials.

Moreover, the color representation allows for a more accurate visual inspection of the fat infiltration. Indeed, the 1-2-3-4 classification used in diagnosis based on patterns of infiltration is retained, thanks to a well-chosen lookup table providing an instantaneous grading without needing to trace ROIs. Although T1w images are considered by radiologists to be most appropriate for anatomical mapping and for determining muscle cross-sectional area or volume, natives images of the VIBE sequence (Figure2), especially when acquired with a 180° phase shift between water and fat, provides anatomical details that have already proved to be efficient for manual or automatic muscle segmentation [5]. The only limitation is a loss in capacity to detect incidental pathology at screening due to the more specialized imaging and representation. With that in mind, whole-body Dixon might overcome the use of whole-body T1w images for diagnostic of neuromuscular disorders.

References

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