Whole body TOF mouse magnetic resonance angiography

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Introduction :
Cardiovascular diseases, such as atherosclerosis, can induce the development of stenosis. These can become critical in pathologies such as coronary heart diseases and necessitate a surgical intervention. A whole body angiography is therefore required to localize stenosis at risk and to target interventions. First-pass magnetic resonance angiography (MRA) on humans provides a non-invasive visualization of blood flow with good contrast between vessels and tissues using Gadolinium contrast agent [1]. However first-pass MRA are hardly used on small animals [2]. Nowadays, time-of-flight (TOF)-MRA is limited to small fields-of-view (FOV) because of its long acquisition times. The aim of this study was also to develop a fast TOF-MRA technique able to get the full angiogram of mouse body with good contrast within reasonable acquisition times. After implementation, this method has been applied to detect and study stenosis on pathologic mouse models.

Materials and methods :
The images have been performed at 9.4T with a Bruker DPX 400 system (Ettlingen, Germany) using a mouse-angiography-dedicated birdcage probe. Fast low angle shot (FLASH) sequence was used (TE/TR = 2/11 ms ; flip angle = 20°). Four acquisitions were needed to obtain the full angiogram of the mouse body. Spatial resolution of the head was 131 x 160 x 151 µm while the mouse body was 131 x 195 x 188 µm, resulting in a total experimental time inferior to 10 minutes. Three different techniques were theoretically and experimentally compared. First classical TOF was used. Then inversion-recovery module was added to TOF and lastly a new FOV signal suppression module was added to TOF.

Results :
The mouse-angiography-dedicated birdcage probe generates high TOF effect. Simulations showed that inversion-recovery and signal suppression modules improved contrast vessels/tissues compared to classical TOF. Besides, signal suppression module was shown to be ideal for tissues with short T1 (fat), and was so preferentially used for abdomen imaging. This new MRA method enabled quickly and simply a complete angiography without contrast agents injection. Then, the 3D data were segmented and enabled a 3D reconstruction of the arterial system. On pathologic models with partial or complete ligation of carotids, the technique allowed detection and distinguishing of the two kinds of stenosis.

Conclusion :
This new method (dedicated probe and adapted sequences) provides 3D high resoluted angiogram of the whole mouse body with good contrast vessels/tissues in reasonable experimental times (within less than 10 minutes). Owing to its high spatial resolutions, this technique enables to detect and study stenosis whatever its position inside the body. This method also appears to be suitable for studying vascular diseases implying stenosis.

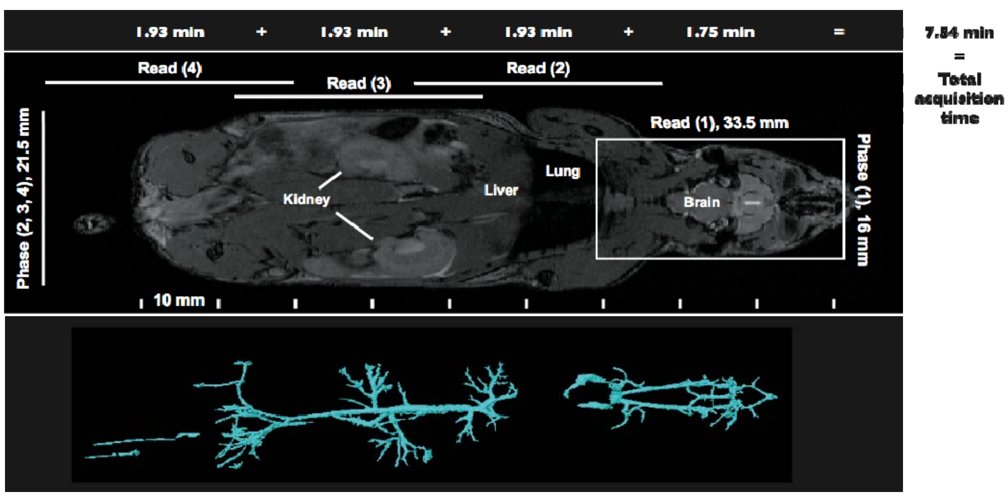

Figure 1 : Angiogram of a whole mouse body. This was achieved with four successive overlapping FOVs (Fig. 1a). Total acquisition time for the whole body angiogram (Fig. 1b) was less than 10 minutes. The 3D data were segmented and enabled a 3D reconstruction of arterial system. The arterial skeleton could be visualised in details at the common carotid arteries and the circle of Willis in the head region, at the aortic arch in thorax or at the hepatic and femoral arteries in the abdominal region.

References :
[1] Kramer H et al., *Eur Radiol*. 2008 Sep;18(9):1925-36. Epub 2008 May 20.
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