Micro-CT based quantification of Mouse Brain Vasculature: The effects of acquisition technique and contrast material

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Introduction

It is understood that radiotherapy of the brain results in cognitive deficits. The causes of the deficits are not well-known, but reduced vascularity may be a significant component of the source of cognitive decline. Animal models to study these effects may assist with understanding the mechanisms. If mouse brain vasculature can be accurately quantified, the effects of radiation on the vasculature might be studied, along with the effects of radiation modifiers such as radio-protectants. This study investigates µCT based quantification of normal mouse brain vasculature, focusing on the effect of two acquisition techniques and contrast material.

Methods

Four mice were scanned on a µCT scanner (Siemens Inveon) using the acquisition and reconstruction parameters listed below.

Acquisition
- Siemens Inveon Multimodal Imager
- Inveon Acquisition Workplace v2.0.0.1050
- Axial acquisition
- 80/50 kVp
- 500 µA
- 720 projections
- 1300 ms per projection
- 17.56 µm slice thickness

Reconstruction
- HU Calibrated
- Feldkamp algorithm
- Noise reduction – slight
- Shepp-Logan filtration
- Mouse beam hardening correction applied
- 18 µm^3 voxel size reconstruction
- 16 bit per voxel
- ~3 Gb per data set

The mice were injected with 40 mg of gold nanoparticles (MediLumine) or 100 µl of Exitron 12000 (Miltenyi Biotec) iodine contrast. Two acquisition techniques were also performed, a single kVp and a dual kVp technique. The single kVp technique scanned the mouse once at 80kVp. The dual kVp technique scanned the mouse twice using 50kVp and 80kVp. The brain was contoured axially and using MatLab the region outside the contour was removed to create just an image of the brain without the high HU skull (Figure 2). For single kVp acquisition, a threshold was applied so the contrast was selectively segmented (Figure 3). For the dual kVp acquistion, the segmentation was based on the ratio of HU between the two kVps. A 3D rendering of the segmented vessels can is displayed (Figure 4). Once a segmented binary image of the vessels was obtained the vasculature fraction was calculated as the number of segmented voxels divided by the total number of voxels brain voxels after removing the skull. this segmentation was based on the ratio of the HU value of the two kVps.

Results and Discussion

The dual kVp acquisition amplified noise of the resultant image and the dual energy technique was not explored further. A second complication was found to be due to the high-resolution acquisition resulting in imperfect source/detector position calibration producing ring artifacts.

For the single kVp acquisition the brain blood volume had an average of 3.5% for gold nanoparticles and 4.0% for Exitron 12000. The contrast-noise ratio was significantly better for images acquired with the gold nanoparticles (2.0) than for those acquired with the iodine contrast (1.4).

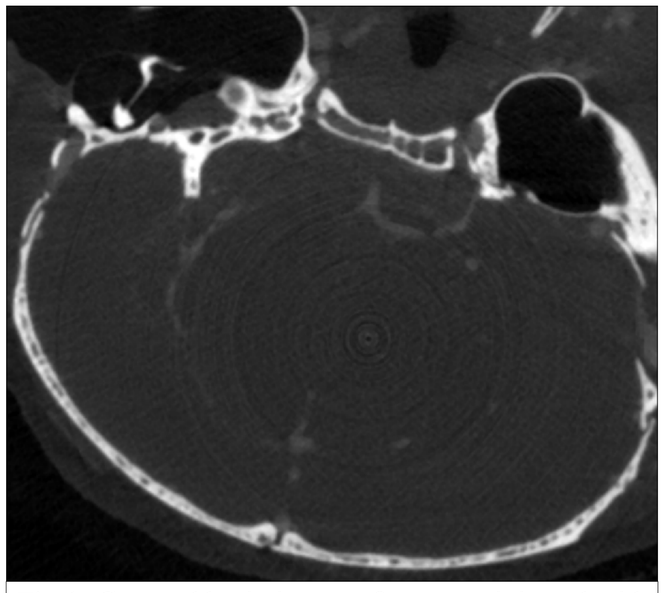

Fig 1- Cropped brain image of a mouse injected with gold nanoparticles

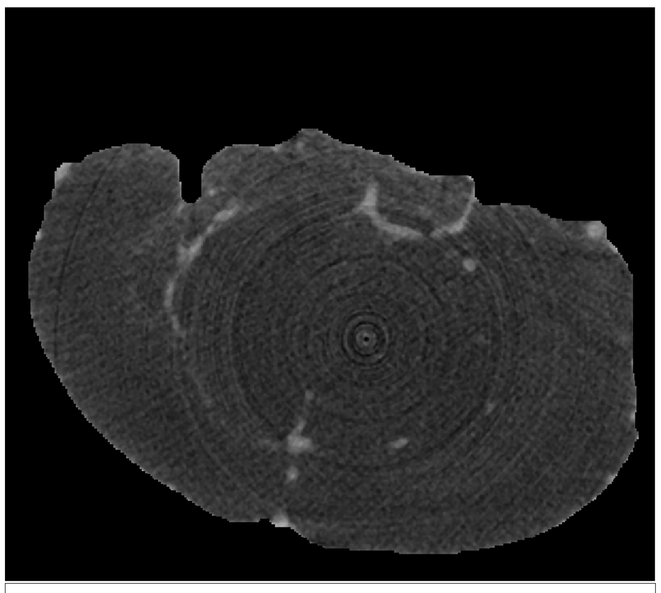

Fig 2- Contoured brain image with the external removed

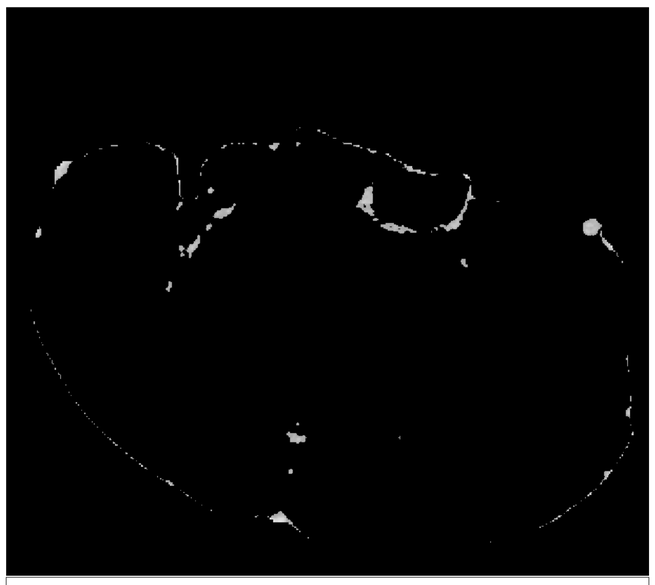

Fig 3- Contoured brain image only showing pixels with a CT number in the range of the contrast injected

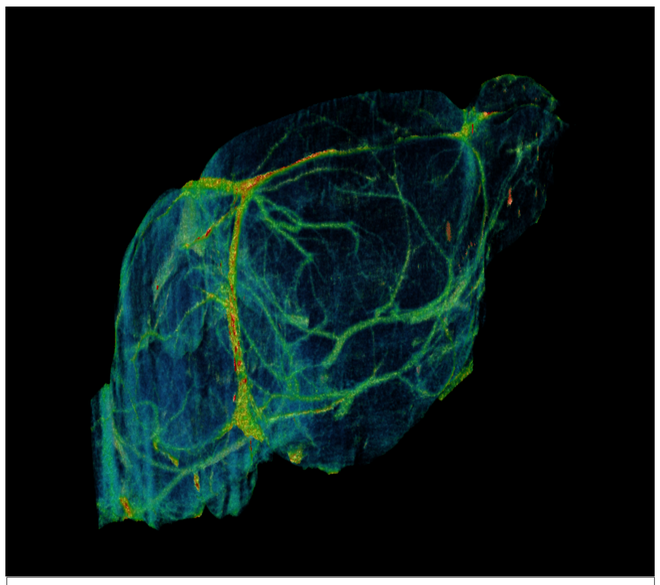

Fig 4- 3D visualization of the vessels

Conclusion

The effects of acquisition technique and contrast material for quantification of mouse brain vasculature showed that gold nanoparticles produced more consistent segmentation of brain vasculature than iodine contrast. Dual kVp acquisition holds some promise for segmenting the contrast agent excluding the boney anatomy, avoiding the need for manual segmentation of the skull although contrast-to-noise remains an issue.

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