Comparison of spinal vasculature in mouse and rat: investigations using magnetic resonance angiography

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Introduction

Spinal vascular system is the conduit through which nutrition, cells and drugs access the parenchyma of the spinal cord (SC). This system is severely damaged as a principal consequence of the spinal cord injury (SCI). The initial vascular damage plays a critical role in establishing the course of the well-established postinjury cascade including compromised blood spinal cord permeability, hypoxia, activation of various factors and, subsequently, secondary injuries. Histological data from experiments with rat and mouse models have indicated that neuropathological differences exist in injury responses between these rodents (Fig. 1) [1]. It is conceivable that these differences may be due to species-specific differences in the vascular organization of the spine. The aim of this study is to test this hypothesis by using magnetic resonance angiography (MRA) as an in vivo imaging tool to visualize the organization of the arterial network in normal mouse spine and parenchyma, and compare it with that of normal rat.

Materials and Methods

All MRI scans were performed on a 9.4 T INOVA Varian system (Varian Inc., Palo Alto, CA) with 31 cm horizontal bore magnet. The data were acquired from male C57Bl/6 mice and Sprague Dawley rats using an inductively coupled surface coil that was placed adjacent to the spine at the thoracic level [1]. The animals were scanned while under isoflurane anesthesia (a mixture of 1.5% isoflurane, 30% oxygen, and air) administrated via nose mask. The physiological condition of the animal was monitored using ECG, respiratory and temperature probes that were connected to an MR-compatible small animal monitoring and gating system (Model 1025, SA Instruments, Inc., Stony Brook, NY). The temperature of the mouse was kept at 37 ^{o}C by circulating warm air with 40 % humidity using a 5 cm diameter plastic tubing fitted at the back door of the magnet bore. Angiograms were acquired using 3D-TOF sequence with the parameters T_R/T_E = 45/4 ms and flip angle (FA) = 45^{o}, and applied over a volume of 18x18x9 mm^3 for mouse and 25x20x20 mm^3 for rat while slab thickness was 7 mm and 16 mm, respectively.

Results and Discussion

The vascular organization of the mouse vertebral column and SC consists of a complex network of arteries delivering blood to the SC from multiple directions and levels (Fig. 2). Anatomically, PIC originates from aorta and branches into smaller projections, such as DB, ARA and ASA. As in humans, a single artery, similar to the artery of Adamkiewicz, supplies blood to the ASA at the thoracolumbar level. The ASA longitudinally runs along the cord, as is the posterior spinal artery on the dorsal site. Parenchymal sulcal arteries branches from ASA and projects radially inwards by the way of the anterior median fissure to a final distribution in the gray matter (Fig. 3). Vasculature in rat spine exhibits close similarity to mouse in terms of its anatomical organization [2].

In conclusion, concerning the part that covers the major arteries and their organization from aorta to the branches of ASA, our data indicate that mouse and rat have similar arterial networks. This result is in agreement with the previous reports based on histological examinations, and suggests minimal participation of this network in defining the different neuropathological responses seen in these species following SCI.

References

[1] Bilgen, M and Al-Hafez, B. Neuroanatomy Online. 5:12-16, 2006.

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Figure 1. (left) *In vivo* sagittal MRIs showing the pathology of injured spinal cords in rat (top) and mouse (bottom) on its chronic phase. Arrow points to the formation of cystic cavity appearing hyperintense region on the rat spinal cord image. Arrowhead points to the formation of a scar appearing hypointense region on the mouse spinal cord image.

Figure 2. (middle) Angiograms showing the anatomy of arteries supplying blood to the mouse spinal cord in axial plane. PIC indicates the posterior intercostal arteries, originating from the aorta at different thoracic levels, DB denotes its dorsal branch, ARA is the anterior radicular artery, ASA is the anterior spinal artery and PSA posterior spinal artery.

Figure 3. (right) Axial views of three sulcal arteries (arrows) in the parenchyma of a mouse spinal cord.