MRI of experimental focal cerebral ischaemia in sheep

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Purpose

A new model of experimental focal cerebral ischaemia by permanent middle cerebral artery (MCA) occlusion in sheep was developed to study therapy for stroke with autologous stem cells from umbilical cord blood. Regarding the specific characteristics of rete mirabile epidural rostra in sheep we aimed to investigate the utility of time of flight (TOF) magnetic resonance angiography (MRA) to observe the vascular anatomy and to validate the MCA occlusion. Furthermore we intended to assess the extent and natural time course of ischaemic focal brain injury in sheep using functional and morphological magnetic resonance imaging (MRI).

Materials and Methods

13 Merino sheep were randomly assigned to one of 5 groups (Fig. 1). Depending on the preserved MCA branches (0; 1; 2; 3; 4) the degree of MCA occlusion was semi quantitatively defined as: 1) no occlusion, 2) sparing of 1 to 2 branches of the MCA, 3) sham operation (no vessel occlusion), 4) occlusion of all branches of the MCA. Following exposure of the MCA branches, the vessels were occluded or touched (sham) by bipolar forceps. Controls did not undergo any surgical procedure. In 10 sheep 23 MRI sessions before and 2 to 46 days after onset of stroke were performed using a 1.5T clinical MRI scanner (Fig. 2). Corrosion casts of the cerebral arteries of 3 sheep were prepared and compared to MCA anatomy in sheep.

Results

MRA visualised vessel anatomy (Fig. 4) or occlusion distal to the rete mirabile. Anatomical variants concerning variant origin of the MCA and inconsistent Arteria choroea rostralis and communicans rostralis were revealed (Fig. 5). Depending on the number of preserved MCA branches (0; 1; 2; 3; 4) the degree of MCA occlusion was semi quantitatively defined as: 1) no occlusion, 2) sparing of 1 to 2 branches of the MCA, 3) sham operation (no vessel occlusion), 4) occlusion of all branches of the MCA.

Conclusion

In our study for the first time focal cerebral ischaemia was generated in sheep and examined using MRI. Depending on the occlusion the model produced reproducible lesion size. TOF-MRA proved to be able to clearly depict the anatomy, variants and occlusion type of the cerebral arteries in sheep comparable to the corrosion casts despite of the upstream rete mirabile. MRI with MRA is a useful tool to assess the extent of brain injury and the type of MCA occlusion and therefore is suitable for non-invasive monitoring of lesion development in stem cell therapy of stroke.