

Pulsed arterial spin labeling in 2-year-old children with congenital diaphragmatic hernia repair and occlusion of the right common carotid artery after neonatal ECMO therapy: Quantitative cerebral perfusion imaging at 3.0 T

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Purpose

Congenital diaphragmatic hernia (CDH) leads to herniation of abdominal organs into the thoracic cavity. Lung hypoplasia and secondary pulmonary hypertension are the major causes of death [1]. In newborns who do not respond to conventional treatment, extracorporeal membrane oxygenation (ECMO) therapy is an alternative to accomplish sufficient oxygenation. In CDH usually veno-arterial ECMO is performed [2]. Vascular access is achieved by insertion of the ECMO cannulas in the right common carotid artery (rCCA) and the right internal vein. At the time of decannulation, ligation or surgical reconstruction of the carotid artery can be performed. The jugular vein is usually ligated [3]. The purpose of this study was to quantify cerebral perfusion in children after CDH repair with rCCA occlusion after ECMO therapy and to assess whether rCCA occlusion leads to impaired cerebral perfusion.

Methods

Pulsed arterial spin labeling (pASL) has the ability to measure cerebral perfusion without applying contrast agent. According to a standardized follow-up program, MR examinations were performed at the age of two years. All children were sedated with intravenous administration of propofol and continuous intensive care monitoring was carried out. Intracranial 3D time-of-flight (TOF) angiography and cervical and pulmonary contrast-enhanced TWIST angiography were performed to evaluate the vascular status of the patients. For pASL, a multislice spin echo EPI sequence with PICORE labeling scheme and Q2TIPS saturation pulses was used [4]. Sequence parameters were as follows: TR/TE 2474.6/21ms, FOV 210x210mm², section thickness 8mm, voxel resolution 2.2x2.2x8mm³, measurements 60, TI1=700ms, TI1s= 1600ms, TI2=1800ms. Imaging was performed at a 3.0 T whole body scanner (Magnetom Trio, Siemens Healthcare Sector, Germany). Cerebral perfusion was evaluated and quantified in 29 children (mean age 2.1±0.2 years, 20 male, 9 female) after neonatal CDH repair. In 14 patients the rCCA was occluded after ECMO therapy (primary ligation or secondary occlusion after reconstruction). The remaining 15 patients without ECMO therapy and normal cerebral blood supply served as controls. Based on ASL images superimposed with T2-weighted morphological reference images, one cortical (containing cortical gray matter) and one subcortical (containing subcortical gray and white matter) region of interest (ROI) was placed in each hemisphere avoiding the inclusion of larger vessels (Fig. 1).

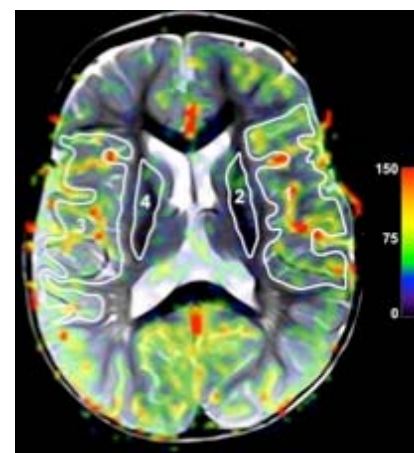


Fig. 1: ASL image superimposed with T2-weighted image. Cortical (1 and 3) and subcortical (2 and 4) ROIs.

Results

Patients with an occluded rCCA showed intracranial (collaterals of circle of Willis) or extracranial (via the right external carotid artery) collateral vessels to maintain bilateral cerebral perfusion. In patients with rCCA occlusion after neonatal ECMO therapy, subcortical perfusion of the right hemisphere was significantly lower compared with the subcortical perfusion of the left hemisphere with a relative cerebral blood flow (relCBF) of 68.8±23.6 vs 79.1±30.5ml/100g/min, p=0.011. Cortical perfusion showed a trend towards a reduced perfusion of the right hemisphere with a relCBF of 65.9±24.5 vs 72.2±29.0ml/100g/min, p=0.138. The control group without ECMO therapy and normal blood flow of the rCCA displayed identical subcortical (56.2±24.2 vs 54.8±26.9 ml/100g/min, p=0.340) and cortical (61.6±25.4 vs 61.2±25.3ml/100g/min, p=0.780) cerebral perfusion in both hemispheres. In nearly one third of the patients with rCCA occlusion, perfusion of the right hemisphere was reduced of more than 20% compared with the perfusion of the left hemisphere (Fig. 2).

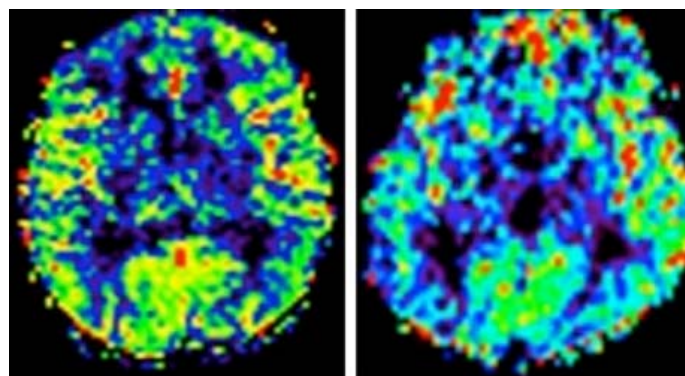


Fig. 2: ASL images. Patient of the control group with normal cerebral blood supply (left) and patient with occlusion of the right common carotid artery after ECMO therapy and lower perfusion of the right hemisphere (right).

Discussion/Conclusion

Arterial spin labeling at 3.0 T is feasible in 2-year old patients to quantify cerebral perfusion. Based on the possible hypoperfusion of the right hemisphere in patients with rCCA occlusion, with possible insufficient collateralisation, reconstruction of the rCCA should be preferred, even if secondary occlusion after reconstruction can occur [2].

References

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