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Case Report

Reversible parenchymal ischemic injury on fetal brain MRI following fetoscopic laser coagulation—Implication on parental counseling[☆]

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ABSTRACT

We present a case of reversible extensive ischemic injury seen on fetal-brain MRI in a fetus following laser coagulation performed for treatment of severe twin-twin transfusion syndrome twin-twin transfusion syndrome. A 32-year-old pregnant mother presented with twin-twin transfusion syndrome. Following fetoscopic laser coagulation, intrauterine fetal death of the donor fetus was diagnosed. On fetal-brain MRI, multiple areas of restricted diffusion were noted, consistent with acute infarctions. Nevertheless, follow-up MRI showed only subtle parenchymal injury, also confirmed on postnatal brain MRI. Our case illustrates that ischemic injury, as depicted on diffusion-weighted imaging, might be reversible, possibly with reperfusion before irreversible insult follows. Two to 3 weeks follow-up fetal MRI might provide additional information on the extent of irreversible injury in cases of restricted diffusion seen on initial fetal-brain MRI and might assist in parental counseling regarding long-term sequela.

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Introduction

Fetoscopic laser coagulation (FLC) is the recommended treatment of severe twin-twin transfusion syndrome [1]. The reported survival of at least one twin is approximately

80%, almost half of pregnancies treated by FLC result in the survival of both twins [2]. However, survivors are exposed to subsequent ischemic-hemorrhagic lesions on brain imaging [3]. Possible pathophysiological mechanisms leading to this in-utero brain injury are hemodynamic changes resulting in cerebral ischemic insult.

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Fetal magnetic resonance imaging has several advantages over prenatal ultrasound, among them improved contrast resolution, better detection of white matter maturation and pathology, visualization of the entire brain, and good visualization of the cortical ribbon [4]. Specifically, brain damage in monozygotic twins has been can be diagnosed by prenatal MRI [5], which might be more sensitive than ultrasound for detecting earlier abnormalities, such as the development of cytotoxic edema and initial cystic necrosis [6]. Perhaps the single most significant MRI sequence in the imaging of acute infarction is diffusion-weighted imaging (DWI) [7]. DWI uses the measurement of the Brownian motion of molecules. The cellular process during a cerebral infarct is a rapid disruption of the sodium/potassium pump and influx of water molecules into the intracellular compartment, that is, cytotoxic edema ensues. Clinical applications of DWI in postnatal life have repeatedly confirmed that cerebral ischemic lesions are detected earlier by DWI than by conventional T2-weighted imaging [8].

Case report

We report of a 32-year-old mother with monozygotic-twin pregnancies, presented to our OB-GYN department on 25 gestational week with significant discordance of amniotic fluid and fetal weight discordance of 24% between the 2 fetuses (estimated fetal weights: 832/627 grams). Smaller fetus had episodes of reverse end-diastolic flow and intermittent absence of end-diastolic flow at the umbilical artery. Normal flow was observed in the ductus venosus and middle cerebral artery. Larger fetus showed normal flows within the umbilical artery, middle cerebral artery, and ductus venosus. Pregnancy was diagnosed as selective intrauterine growth restriction type III with suspected twin-twin transfusion syndrome stage III. Fetoscopic laser ablation was performed to 7 placental anastomoses at 25 weeks + 2 days. Three days following the procedure, intrauterine fetal death of the donor fetus has been diagnosed. Fetal brain MRI has been performed 5 days after the laser procedure at 26 weeks + 0 days, for evaluating possible brain injury in the surviving recipient. On DWI, multiple areas of restricted diffusion (increased DWI signal accompanied with low ADC values) were demonstrated in the operculum bilaterally as well in occipital lobes (Fig. 1 B-C, G-H, and L-M). Right parieto-occipital white matter also showed moderate restricted diffusion (figure L-M). T2 weighted images showed mild cortical edema (figure A, F, K). Repeated MRI performed 2 weeks after the first MRI showed normalization of diffusion changes with only subtle cortical irregularities on previously seen cortical restricted diffusion (figure D and I). The fetus was delivered prematurely by emergency Cesarean section at 29 weeks+ 4 days of gestation due to premature rupture of membranes, contractions, and breech presentation. A 1290 grams male fetus was born with Apgars 6/8. Brain MRI, performed at age of 5 weeks, showed minimal cortical irregularities on the left occipital and right opercular regions. Otherwise, brain MRI is unremarkable (figure E, J and O).

Discussion

Shortly following the rapid decrease in regional blood flow, energy-dependent processes are compromised. An early result of this energy failure is extensive ion disequilibrium, with potassium ions leak out of the cells, and sodium and calcium ions enter the cells [9]. Water follows the osmotic gradient into cells, resulting in cytotoxic edema. It is evident that this cytotoxic edema is associated with impairment of proton diffusion detected by DWI and can be measured on apparent diffusion coefficient (ADC) maps. This lesion, of increased DWI signal with low ADC values, is thought to represent tissue with irreversible damage, that is, DWI depicts what is deemed to be the infarction core [9,10].

Nevertheless, a recent understanding of stroke pathophysiology based on reperfusion results following acute infarctions illustrates that neuronal injury depends mainly on the decrease in cerebral blood flow (CBF) and the time of ischemia before reperfusion. For example, at CBF below 10 ml/100 g × min, neurons die within 30 minutes, but survive indefinitely at a CBF above 15 ml/100 g × min. ADC declines immediately when CBF falls below 20–40 ml/100 g × min [11]. High-signal lesions on DWI representing cytotoxic edema can disappear with reperfusion but are closely associated with infarction if persistent, as shown in animal and clinical studies [12,13]. DWI identifies brain regions suffering from severely decreased CBF and, thus, tissue regions that may not survive without blood flow restoration.

In fetuses following FLC, hemodynamic changes lead to regional decreased CBF, seen as areas of restricted diffusion on DWI. These areas might evolve into overt infarction with encephalic changes if persistent. Our case illustrates that if these changes might be transient and, CBF normalized before irreversible insult follows, residual findings on imaging might be only subtle, if any. These findings have a critical influence on parental counseling in cases of suspected ischemic injury, specifically in twin pregnancy, following FLC for twin-twin transfusion syndrome and in cases of demise of one of the fetuses. As currently no direct continuous perfusion imaging is performed routinely on fetal MRI, definite estimation of the extent of infarcted parenchyma is limited on initial MRI performed acutely following FLC treatment of twin-twin transfusion syndrome. As such, we suggest that in cases of suspected fetal brain acute ischemic injury following FLC treatment, follow-up fetal brain MRI (performed 2 to 3 weeks following the FLC treatment) might provide additional information on the extent of parenchymal injury and might assist in parental counseling regarding long-term sequela.

In conclusion, high-signal lesions on DWI on fetal brain MRI, consistent with acute cytotoxic edema and infarction, do not necessarily represent irreversible parenchymal injury, as previously thought. In such cases of suspected acute fetal brain ischemia and restricted diffusion on early MRI, follow-up fetal brain MRI might provide additional information on the extent of irreversible injury.

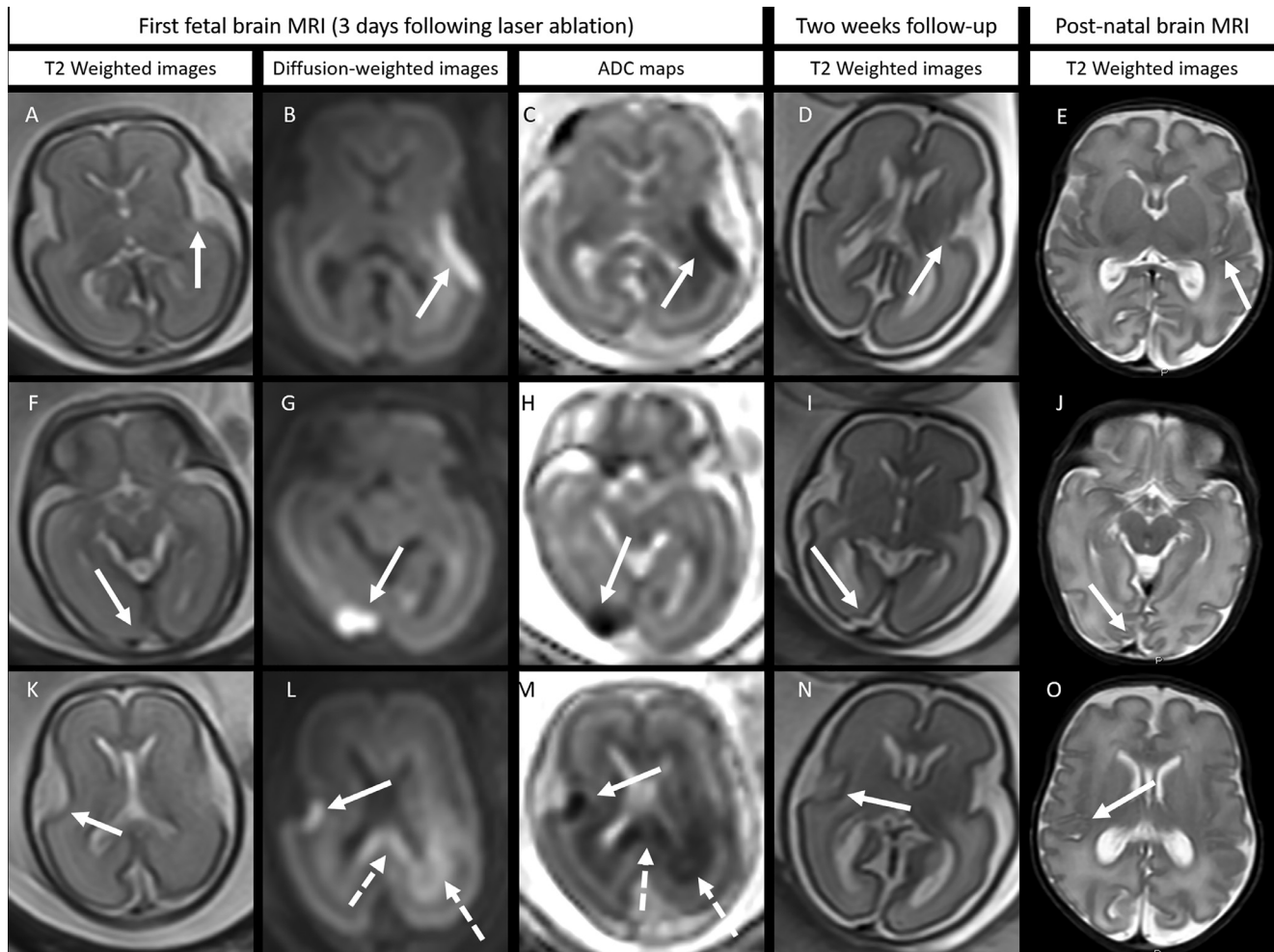


Fig. 1 – Fetal brain MRI of the survived recipient fetus performed 5 days following the laser procedure, showing multiple areas of mild cortical edema and marked restricted diffusion on left operculum (arrows on A–C), right occipital lobe (arrows on F–H). Images K–M shows area of restricted diffusion suggestive for infarction also in the right operculum (arrows). Notice confluent restricted diffusion also in the left peri-atrial white matter and within the splenium of the corpus callosum, which is also suggestive for ischemic injury. Two weeks follow-up fetal brain MRI shows only subtle areas of cortical irregularities (arrows on D, I) with normal-appearing right operculum. Postnatal brain MRI has confirmed subtle findings, as seen on the two weeks follow-up study (arrows on E, J, and O).

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None.

Statement of Ethics

This case report has complied with the guidelines for human studies.

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None.

Author Contributions

All authors have substantial contributions for the submitted case report.

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