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## Usefulness of magnetic resonance imaging with SWI sequence (susceptibility-weighted imaging) in diagnosing cerebral hemosiderosis – case report

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### Summary

**Background:**

The purpose of this study was to determine whether the SWI sequence may improve the MRI evaluation of hemosiderin deposits in the brain.

**Case Report:**

We report a case of a 7-year-old girl after a total resection of a large tumor mass (ependymoma G II) located in the left hemisphere. Late complication of surgery was hemosiderosis of the brain diagnosed with SWI sequence.

**Conclusions:**

SWI sequence is very sensitive in diagnosing hemosiderin deposits. It allowed us to recognize cerebral hemosiderosis in this case. We suggest to include this sequence in routine MRI examinations of the brain, especially in cases of potential and suspected intracranial bleeding

**Key words:**

magnetic resonance imaging • SWI (susceptibility-weighted imaging) • hemosiderosis • hemispherectomy • children

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### Background

SWI sequence, i.e. imaging depending on magnetic susceptibility, is a relatively new sequence used in MRI examinations. It is becoming a routine practice due to its usefulness in diagnosing diseases accompanied by iron deposition and calcifications [1].

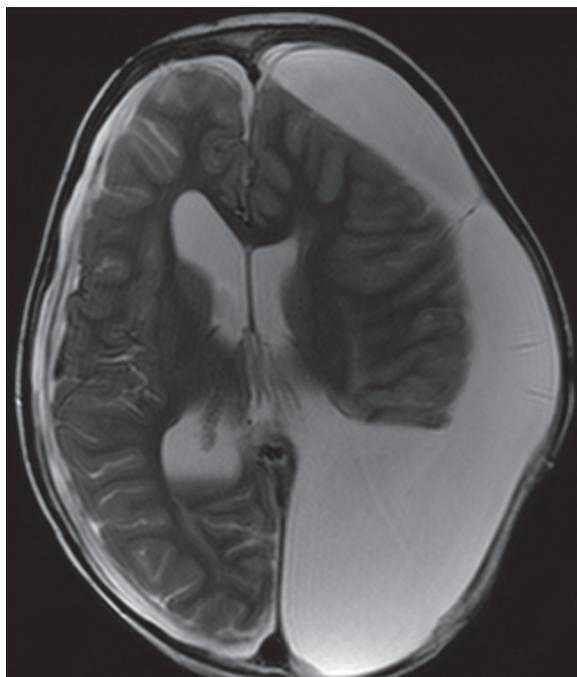
SWI is especially useful in diagnosing brain areas that underwent even slight disturbances of the magnetic field homogeneity.

One of the causes of changes in the local homogeneity of the field is the presence of blood/hemosiderin inside the brain or pericerebrally. Due to that fact, SWI sequence reveals a high sensitivity in diagnosing microcalcifications, several times higher than the one presented by other, previously used, T2-weighted gradient-echo sequences.

We present a case of a seven-year-old girl subjected to a total resection of a large tumor mass of the left hemisphere (ependymoma G II) who developed (as a late postoperative complication) cerebral hemosiderosis diagnosed with the use of SWI sequence.

### Case Report

The seven-year-old girl was admitted to the Neurosurgical Department at the beginning of July 2007 due to a CT- and MRI-diagnosed large tumor mass of the left posterior hemisphere with a mass effect, dislocation of the midline structures and an active external hydrocephalus. The tumor was located in the parietal-temporal-occipital region within the trigone of the left lateral ventricle of the brain. The main clinical symptoms were the increased intracranial pressure and macrocrania. An extensive craniotomy of the left parietal-temporal-occipital led to a total tumor resection with an opening of the left lateral ventricle of the brain.



**Figure 1.** FSE T2-weighted image, transverse plane: hemorrhage inside the posterior horn of the right lateral ventricle.

Histopathological examination showed ependymoma grade II- ependymoma partim clarocellulare WHO G II.

The operation was complicated by an epidural abscess at the site of craniotomy. It was treated surgically by removal of an osseous flap and implantation of a temporal epidural drainage. Further treatment was conducted at the Department of Oncology, where the patient received 4 courses of chemotherapy, and then, from December 2007 to January 2008, a two-phase radiotherapy of the whole CNS: in the first phase it was 2505 cGy/t in 15 fraction doses, in the second phase: 5385 cGy/t destined for the postoperative field and a higher dose – of 4000 cGy/t – for the Th8-S3 spinal canal. After a completed radiotherapy, seven courses of maintenance chemotherapy were introduced according to the Packer regimen.

During the comprehensive treatment, the child was subjected to routine follow-ups at the MRI Laboratory, with an aim to have the efficacy of the introduced treatment assessed.

The examinations were performed with the use of a 1.5T scanner and a 8-channel head probe, in three planes, T2- and T1-weighted images, and two phases. They found an extensive postoperative field reaching the left lateral ventricle and a large fluid collection surrounding the left hemisphere. For further diagnostics, SWI sequence with the following parameters was used: bandwidth: 90 Hz/Px, TR/TE: 58.0/44.1 ms, FOV: 230×230 mm, matrix: 320×320, GRAPPA 3, section thickness: 1.6 mm, gap: 20%, flip angle: 19, number of averages: 1, voxel: 0.7×0.7×1.6, acquisition time: 7 min.

In a subsequent routine MRI examination carried out 19 months after the surgical procedure, the TSE T2-weighted

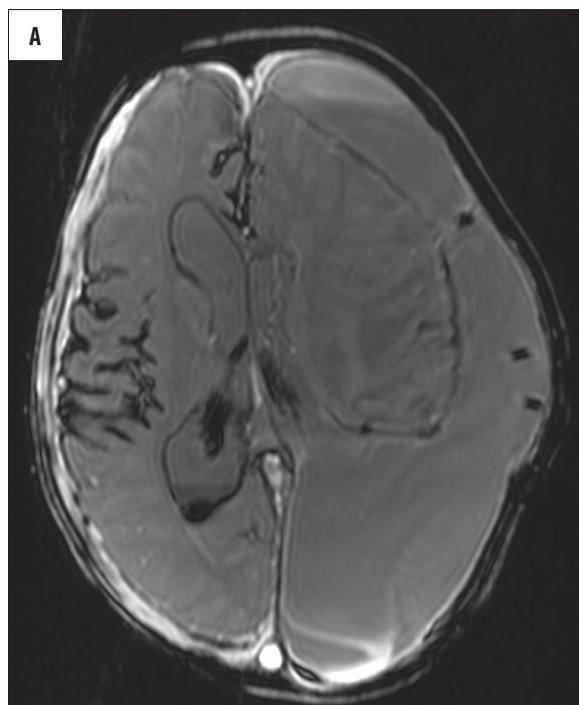
images showed a decreased signal intensity on the surface of the medulla oblongata and part of the cerebral hemispheres, as well as a chronic hematoma in the right ventricle. Figure 1. SWI sequence showed it more precisely and extensively: linear, non-signal producing lesions on the surface of the cerebellum, brain, medulla oblongata, and along the ependyma of the ventricles of the ventricular system; in the right occipital horn – a chronic hematoma with fluid. Figure 2A–C. Basing on that, a postoperative hemosiderosis of the brain was diagnosed. In February 2009, a further neurosurgical operation was performed. It was meant to fill the extensive bone defect in the cranial vault with an artificial material (cranioplasty).

## Discussion

Cerebral hemosiderosis is nowadays a very rare late complication of extensive neurosurgical procedures. It is mostly connected with anatomical hemispherectomy (surgical method of hemisphere removal, saving basal ganglia). Anatomical hemispherectomy as a technique of brain tumor treatment was first published in 1928 – a procedure of glioma resection conducted and described by Walter Dandy [2]. In the following years, this technique was mostly used in patients with epileptic seizures, resistant to pharmacotherapy. The following early postoperative complications were reported: aseptic meningitis connected with the passage of products of blood lysis to the cerebrospinal fluid, dislocation of the remaining part of the brain and its herniation towards the postoperative hole, as well as hydrocephalus. The next years witnessed quite frequent (i.e. in 33% of cases) serious late postoperative complications in the form of superficial hemosiderosis of the brain, as well as spontaneous and traumatic hematomas [3,4]. The formation of hematomas is promoted by an 'empty' space left after anatomical hemispherectomy. Hydrocephalus and hemosiderosis of the brain were the main complications and the cause of death in those patients.

Pathomechanism of hemosiderosis is not fully understood. It is believed that the direct cause of this complication is bleeding (superficial subarachnoid and intraventricular) connected with enormous distortions of normal anatomical relations of the brain – 'the empty space' after the resected hemisphere [5]. With long-lasting or recurrent subarachnoid hemorrhages, hemosiderin is deposited on the surface of the brain, cerebellum, spinal cord and cranial nerves. Frequent complications include deafness, ataxia and smell disturbances [6]. A typical location of those lesions is the surface of the brain stem and cerebellar hemispheres. Histopathological examinations tend to show deposits of hemosiderin covering the surface of the brain and the ependyma of the ventricles, i.e. regions remaining in a direct contact with the cerebrospinal fluid. They cause gliosis, neuronal loss and demyelination. Two types of glial cells take part in the process of hemosiderin deposition: microglia, synthesizing ferritin, and Bergman's glial cells, which are the source of iron and also take part in synthesizing ferritin [7,8].

In the literature, there are reports on cases of hemosiderosis caused not only by anatomical hemispherectomy, but also by brain tumors, e.g. ependymomas or astrocytomas



of the cerebellum, venous malformations, as well as amyloid angiopathies and radiotherapy [9–11]. In order to limit the risk of the aforementioned complications, neurosurgical modifications of anatomical hemispherectomy or functional hemispherectomy are applied [12].

In the case presented by us, the operation consisted in a selective resection of a massive tumor destroying the posterior part of the left hemisphere. Due to a slow growth of the tumor mass, there appeared some atrophic lesions of the brain in that region, connected with compression exerted by the tumor. There was a large asymmetry between the hemispheres. Due to the tumor growth and widening of the brain ventricles, the size of the brain increased, leading to an excessive increase in the circumference of the child's head (macrocrania). After resecting the large tumor mass and opening the ventricle of the brain, the internal hydrocephalus resolved and there appeared a significant disproportion between the brain size and the volume of the skull. This led to a substantial subarachnoid fluid collection and created conditions similar to the ones observed in patients after anatomical hemispherectomies.

A very important factor predisposing to the presented complication was the presence of the extensive bone defect in the cranial vault in the left parietal-temporal-occipital region. This caused abnormal fluctuations in the intracranial pressure, depending on the body position and patient's activity status. Periodically, the child experienced disturbances in blood coagulation connected with the introduced radio-/chemotherapy, which contributed to the appearance of the aforementioned posthemorrhagic complications.

At present, due to the development of the state-of-the-art neurosurgical techniques, cerebral hemosiderosis, being solely the consequence of surgeries, is diagnosed very rarely.



**Figure 2.** (A) SWI sequence, (B) transverse planes and (C) sagittal plane: laminar loss of signal intensity around the brain stem, cerebrum and cerebellum, which indicates hemosiderin deposition. Hemorrhage inside the posterior horn of the right lateral ventricle.

A rapid development of different diagnostic methods, including the MRI, contributes not only to a better planning of neurosurgical procedures, but also to a more precise recognition of postoperative complications. An example for that would be the introduction of MRI imaging with SWI sequence. This is a 3D gradient-echo sequence with a very high spatial resolution. This type of imaging was primarily used for visualization of the venous system, as it applies the pragmatic properties of deoxyhemoglobin running in veins [13]. Soon, it turned out that SWI uses the differences in magnetic susceptibility of tissues which cause differences in phases between regions including paramagnetic

blood products (deoxyhemoglobin, intracellular methemoglobin and hemosiderin) and the surrounding tissue [14]. This all led to an increase in the number of indications to SWI use. It was found that this sequence provides additional information, very useful in the diagnostics of brain injuries, coagulopathies, vascular malformations, tumors and degenerative diseases accompanied by iron deposits and calcifications [15,16]; but the most valued property of SWI was its sensitivity in diagnosing extravasated blood [17,18].

SWI sequence is a method with the highest sensitivity in detection of foci of microhemorrhage; according to some authors, six times higher than the conventional T2-weighted gradient-echo sequences [19–21]. This concerns both the size and the number of foci, as well as the volume of extravasated blood.

Moreover, in the study on MRI presented by us, the application of the SWI sequence allowed for the detection and imaging of an actual extension and of a precise location of hemosiderin deposits on the surface of the brain, cerebellum and ventricular system.

## Conclusions

In the presented case, we found the SWI sequence to be useful in diagnosing the presence and extension of the areas of extravasated blood. MRI with this sequence allowed for the detection of an extremely rare complication of the surgical procedure, i.e. cerebral hemosiderosis. Authors suggest that SWI sequence should be included in the set of routine MRI procedures, especially in the cases of extensive neurosurgical procedures, as well as in many other pathologies of the CNS that may be complicated by intracranial bleeding.

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