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Comparison Between The Time-SLIP Images of Two Cases With Giant Arachnoid Cyst And Aqueduct Stenosis Under Neuroendoscope Assist

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***Abstract*—Purpose : Cerebrospinal fluid (CSF) flow can be characterized by its speed and also qualitatively as laminar or turbulent. These characteristics depend on pressure and compliance in the CSF spaces, together with any propagated pulsations. By using the unenhanced time spatial labeling inversion pulse (T-SLIP) technique, it became possible to visualize CSF movement noninvasively, regardless of physiological conditions. We observed two cases with very similar pathology, which further on had very different clinical courses and we discuss the role of T-SLIP demonstrated CSF dynamics.**

Methods: We had the opportunity to treat 2 patients who suffered from repeating headache episodes and diagnosed with arachnoid cysts in the left cerebellar hemisphere. Both cases were treated by surgery, performing cyst fenestrations. We performed T-SLIP examinations before and after surgery.

Results: Although both cases showed the same condition, T-SLIP results clearly differed after the operation. The first case showed substantial CSF outflow from the cyst on T-SLIP images and there was a good clinical outcome with cyst size reduction as seen on MRI images and confirmed by the disappearance of headaches. On the other hand, the case in which postoperative T-SLIP images showed restricted CSF movement needed a C-P shunt after the initial operation.

Conclusions: While still having limitations, T-SLIP method has the potential to estimate functionally not only for the current condition of new CSF paths, but suggest the future clinical course of these patients.

***Index Terms*— Time SLIP, arachnoid cyst, cerebrospinal fluid flow, visualization**

I. INTRODUCTION

Cerebrospinal fluid (CSF) hydrodynamics changes are an important factor determining the nature, progress and outcome of CSF compartment related pathology.[1-3] In cases of arachnoid cysts the treatment policy may differ among institutions, and depends on estimations of pressure gradients and flow characteristics. In such types of pathology, often seen in children, an easy non-invasive method of CSF hydrodynamic assessment can resolve a substantial number of questions on decision making for treatment. [4-6]By using the unenhanced time- spatial labeling inversion pulse (SLIP) technique, noninvasive visualization of CSF movement including bulk and turbulent flow became available for evaluation, regardless of patient physiologic conditions, and applicable to adult and pediatric patients, who are not suitable for lumbar puncture or cineMRI.[1, 4-6]

It became possible to visualize flow characteristics in such areas as the prepontine cistern and convexital subarachnoid spaces. The objective of this study was to demonstrate the value of the time-SLIP method, emphasizing on the differences detected between two similar cases.

II. CASES AND OPERATIVE TECHNIQUE

A. Case1

A 16 year-old girl with a history of repeated headache episodes was diagnosed with a temporal arachnoid cyst expanding over the left hemisphere in the frontal, temporal and sphenoidal areas. In the preoperative T-SLIP, there is no flow between the ambient cistern and the arachnoid cyst, and no fluid movement was observed in the cyst. Through a small craniotomy a fenestration of the cyst was created, reestablishing free communication with subarachnoid spaces. After surgery, she was relieved from headache. On the postoperative T-SLIP study, a brisk CSF motion not seen on the preoperative views was evident (Fig1). It showed CSF passing through the fenestration of the cyst. At present, she is headache-free. Follow-up MRI 3 months after surgery (Fig2) showed volume reduction of the cyst.

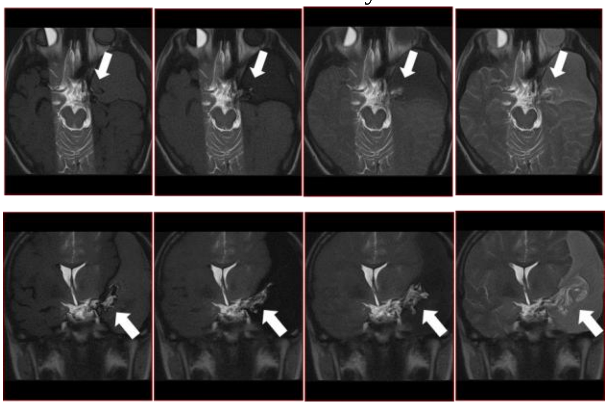

Fig 1：A series of time dependent axial and coronal T-SLIP images on after operation (ETV) in case1. The high signal intensity (arrows) on these images indicates CSF flow from

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the cistern into the arachnoid cyst through the fenestrated part. This flow indicates active CSF exchange between the cistern and cyst.

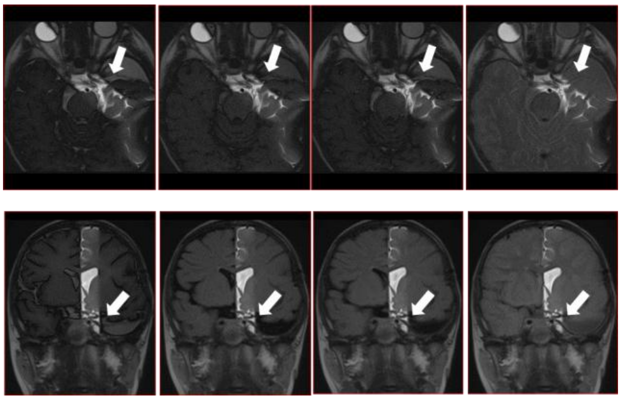

Fig 2：A series of time dependent axial and coronal T-SLIP images after operation (ETV) in case 2. The high signal intensity (arrows) on these images indicates CSF flow from the cistern into the arachnoid cyst through the fenestrated part. This flow indicates limited CSF exchange between cistern and cyst.

B. Case2

A 4 year-old boy had a history of repeated headache episodes. MRI showed an arachnoid cyst in the left cerebellar hemisphere. Within 1 year the cyst enlarged and scalloped the temporal bone on the same side. We evaluated the patient for communication between the subarachnoid spaces and the cyst and the T-SLIP study did not show CSF flow. Similar to case 1, the cystic wall was widely fenestrated through a small craniotomy. After operation, his headache temporarily improved, but recurred again. On the T-SLIP image after operation, the CSF flow through the fenestration was minimal (Fig3). A week later, CT showed cyst shrinkage but also increased subdural and subcutaneous effusion. We had to place a cysto-peritoneal shunt one month after the initial operation to resolve the effusions. At present he is asymptomatic (Fig4).

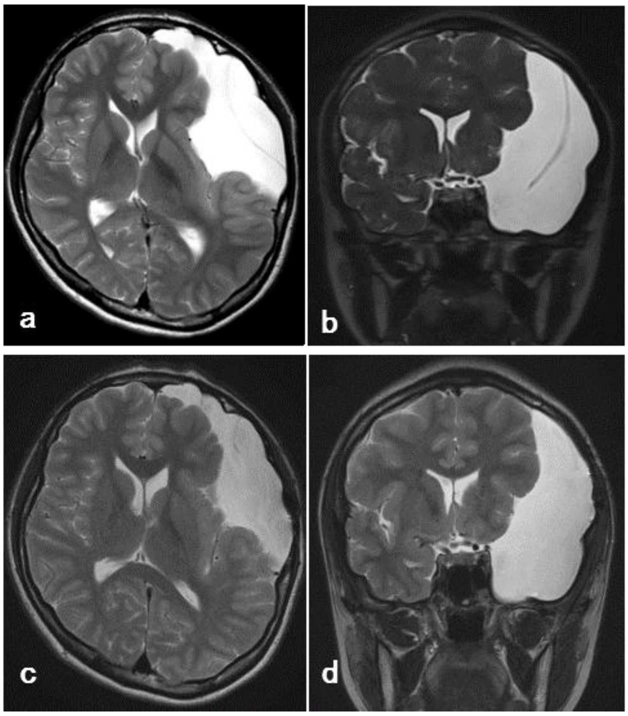

Fig 3：The axial and coronal T2 images before and after operation (ETV) in case1. The lower images (c,d) indicate slight shrinkage of the arachnoid cyst after ETV.

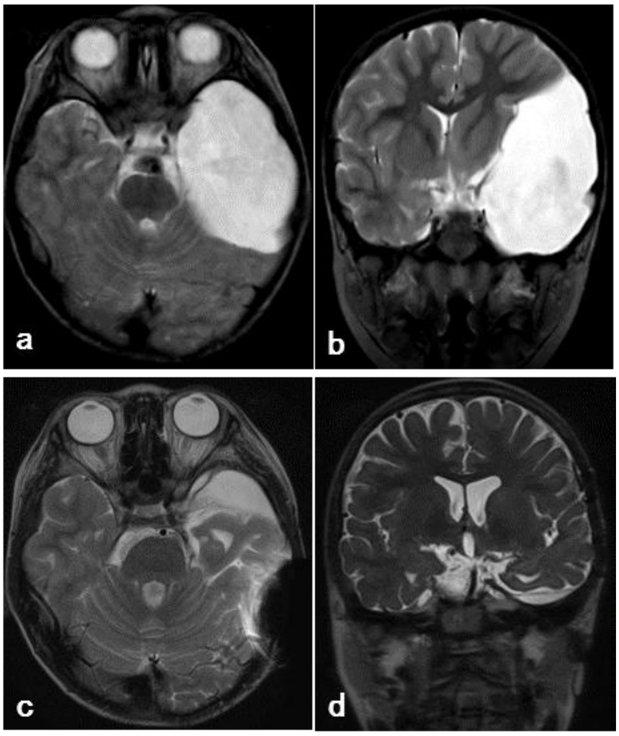

Fig 4：The axial and coronal T2 images before and after operation (VP shunt) in case 2. The lower images (c, d) indicate significantly shrunk arachnoid cyst after VP shunt.

III. Result

＜Comparison of two cases＞

Both cases had similar clinical presentation and evolution. Their clinical findings were similar and pre-operative imaging had common characteristics. However T-SLIP postoperative images differed significantly and that matched the outcome with the flow through the surgical fenestration.

T-SLIP images that indicated significant and brisk flow corresponded to better patient outcome. While fenestration might be persisting, the value of understanding the flow characteristics through it can contribute to the prediction of prognosis in this kind of surgery.

Reduced flow through the fenestration can indicate either lack of pressure gradient between cyst and cisternal spaces or malfunction of the fenestration. Such kind of flow reflects an unsatisfactory pressure reduction in the cyst, and respectively improvement of symptoms would not be observed. The lack of quantitative expression in the T-SLIP method makes speculative the consideration of pressure/volume dynamic parameters, but semi-quantitative expression estimation can be obtained. Correlating it with the outcome has shown value for comparison in outcome and possible prognostic value with the accumulation of further experience. In our institution we always attempt initially to fenestrate the cyst to the CSF spaces with normal CSF dynamic, and if only that fails, shunts are placed. As the management guidelines still need to be refined in certain category of cases, prognostically valuable techniques can improve decision making, and outcome respectively.

IV. Discussion

Initially, middle cranial fossa arachnoid cysts were believed to arise secondary to primary temporal lobe hypoplasia.[7] After recognizing the intra-arachnoid location of these cysts, it has been postulated that they arise due to splitting of the arachnoid membrane in the early intrauterine developmental period and secretion of CSF within the cyst cavity.[8, 9] The mechanism of cyst expansion is unclear and it was postulated as CSF pumping through persisting communication pathways between the cyst and CSF due to venous and arterial pulsations.[10, 11]

Endoscopic treatment has been used to treat arachnoid cysts, but the best surgical treatment remains controversial. Cystoperitoneal shunting (CPS) is a technically easy procedure that leads to early obliteration of the cyst, but is associated with a high shunt malfunction rate (up to 40%).[12] Another disadvantage of CPS is the high incidence of shunt dependency (up to 42%), which makes children with shunts and their parents feel worried all their lives due to the risk of pseudotumor cerebri after a possible shunt malfunction.[13, 14] With these considerations in mind, craniotomy and arachnoid cyst marsupialization, which is a shunt-independent approach, is considered to be a more favorable option. However, this is an invasive approach that carries the risk of major complications such as neurological deficits (hemiparesis), meningitis, subdural hematomas, and seizures.[15]

In our institution we use EXCELART Vantage Titan 3T MRI machine (Toshiba, Tokyo, Japan) with quadrature-detected phase-array coil (five channels) (QD-Head PEEDER: Toshiba). Although T-SLIP allows observing CSF motion in real time for about 6 seconds, a big difference in the result may arise from differences in setup and part of the range called tag. That is, the flow which originally exists by the slight gap of tag may be undetectable.[16] Therefore it is shown that a result may change with positions which each doctor and medical technologist set up. In order to reduce the differences that can appear at this step of the study, in our hospital the tag is set by a single team (doctor and medical technologist).

Moreover, to easily compare the observation of clinical change in the same patient and between other patients, the tag is set always in the regular part. The term “regular part” is an intracranial area usually characterized by persisting CSF flow on MRI, for example the foramen of Monro or the cerebral aqueduct areas. The result of T-SLIP gives important information as an additional diagnostic tool for understanding the pathophysiology of the condition and determining appropriate treatment. From our previous experience, this technique was very effective especially for patients with aqueductal stenosis (AS). For example, for the case illustrated on (Fig5) we were able to detect accurately the CSF flow and patency of the aqueduct unknown before surgery. The preoperative T-SLIP of this case where aqueduct occlusion was suspected showed turbulent flow in the fourth cerebral ventricle, confirming patency. That was supported by the intraoperative endoscopic finding (Fig6). After endoscopic third ventriculostomy (ETV) surgery, we recognized the appearance of significant CSF flow change, in the fenestration area and the resumption of flow through the foramen Monro by T-SLIP. The turbulence seen on the preoperative T-SLIP in the IV ventricle nearly disappeared, and the route of the CSF outflow changed. This patient had good outcome and no recurrence. For such patients a V-P shunt might be chosen as a first line of treatment depending on the institution. Pediatric V-P shunting complications are creating difficulties of management, which is well known in this field. In our experience, when the T-SLIP shows no or poor flow of the aqueduct shunt independence can be expected after ETV.

The T-SLIP tends to be affected in revealing CSF dynamics not only by tag setup. In some cases, even if T-SLIP results seem the same, clinical course might be completely different. Therefore, T-SLIP has extremely high specificity, whereas negative effects by tag setup imply decreased sensitivity. The interpretation of T-SLIP requires consideration of the symptoms and clinical course of the disease. As previously noted, in future the T-SLIP will be supposed to express quantification of CSF flow, definition of normal values and establishment of other significant characteristics with potential clinical significance. Although still being complementary to clinical practice, T-SLIP has the potential to provide new data for understanding hydrocephalus mechanisms and have some indications on its pathophysiology with an objective, non-invasive and reproducible method.

Furthermore, evaluating normal CSF dynamics, we can detect differences by T-SLIP that might elucidate normal variations. This will improve the understanding of margins of normal and abnormal for this new method.

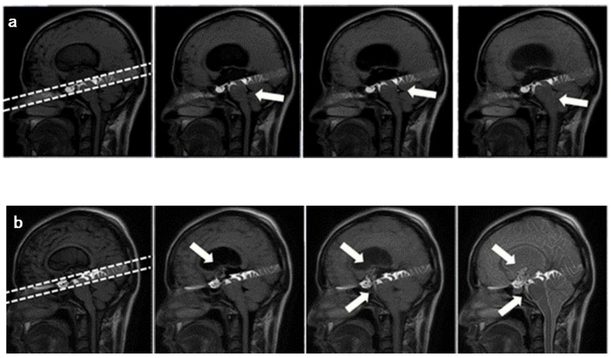

Fig 5：A series of time dependent sagittal T-SLIP images before (a) and after (b) operation (ETV) in aqueduct stenosis case. The low signal intensity (arrows) on image (a) indicates slow CSF flow from the third ventricle into the fourth ventricle through the aqueduct. This flow indicates limited CSF exchange between third and fourth ventricle.

The high signal intensity (arrows) on image (b) indicates CSF flow from the prepontine cistern into the third ventricle through the floor of third ventricle fenestrated part. This flow indicates the ETV works effectively.

Fig 6 : Operative view of neuroendoscopy proved the narrowing the aqueduct itself.

V. Conclusion

We experienced two cases in similar clinical conditions, in which results of T-SLIP indicated the eventual clinical course and the difference of outcome after surgery. These observations indicate that the method may have the potential to evaluate the CSF dynamic condition implicating prognostic value.

APPENDIX

The authors have no personal financial or institutional interest in any of the materials or devices described in this article.

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