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Intraventricular Fluid Injection as a Novel Treatment of Subdural Fluid Collection after VP Shunt Overdrainage: A Case Report

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Abstract

Introduction: Subdural fluid collection is one of many complications of ventriculoperitoneal (VP) shunt. Variety of surgical procedures have been applied for the treatment of the post VP shunt subdural fluid collection, but the ideal surgical treatment remains controversial.
Case Report: This is a case report of 14 years old boy who had a history of multiple VP shunt revisions for post hemorrhagic hydrocephalus with subdural fluid collections due to cerebrospinal fluid (CSF) overdrainage.
Result: The author performed intraventricular fluid injection via shunt valve to expand the brain mantle and drain the subdural fluid through a small craniotomy. This is the first case report using the novel "fluid infusion" technique for the treatment of intractable subdural fluid collection after the VP shunt overdrainage.
Conclusion: The technique can bring potentially great impact for the future treatment of symptomatic subdural fluid collection associated with CSF overdrainage after VP shunt.

Keyword: hydrocephalus, intraventricular fluid collection, subdural fluid collection, ventriculoperitoneal shunt

Introduction

Ventriculoperitoneal (VP) shunt is a common neurosurgical procedure and is a golden standard treatment for hydrocephalus, however, complication rates in the pediatric population remain considerably high. VP shunt failure rates have been estimated approximately 11 – 25% within the first year after initial shunt placement [1][2][3]. Merkler et al also reported another follow up to second and fifth year after shunt placement, the complication rates respectively are 5.7% and 2.5% [3]. The young age of the patient means the patient will always be at risk for VP shunt complications throughout his or her life.

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Many VP shunt complications have been reported, such example is obstruction of the catheter, infection, pseudocyst formation, bowel perforation, shunt migration and so on [4]. One of the complications that can be found is the subdural fluid collection after VP shunt installation due to overdrainage [4]. While some subdural collections can resolve spontaneously, others may grow to cause significant mass and need surgical decompression [5]. The ideal surgical treatment of subdural fluid collection for children remains controversial. Different studies propose the use of percutaneous transfontanellar puncture, external drainage, subduroperitoneal shunt, craniotomy and subgaleal shunt [6]. Attachment of anti-siphon device and shunt valve replacement to a programmable one also help reducing the risk of subdural recollections [7].

In this case report, the authors described a novel treatment of subdural fluid collection caused by the cerebrospinal fluid (CSF) overdrainage after VP shunt. We preferred to use the term “subdural fluid collection” instead of “subdural hematoma” or “subdural hygroma” because subdural fluid collection involves both pathologies of “hematoma” and “hygroma”.

Case Report

Fourteen years old boy had had a history of multiple VP shunt revisions for post hemorrhagic hydrocephalus since his neonatal period. The last shunt revision was carried out 7 months before his referral to Tokyo Metropolitan Children’s Medical Center (TMCMC) using a programmable shunt valve. The ventricular catheter had been inserted from the left posterior horn. Following the last shunt revision, subdural fluid collection (hematoma) developed and the valve pressure was adjusted up to the maximum pressure with no improvement of the subdural hematoma. A contrast enhanced CT scan taken after his transfer to TMCMC revealed tri-layered multi compartmented subdural hematoma with severe midline shift (Figure 1).

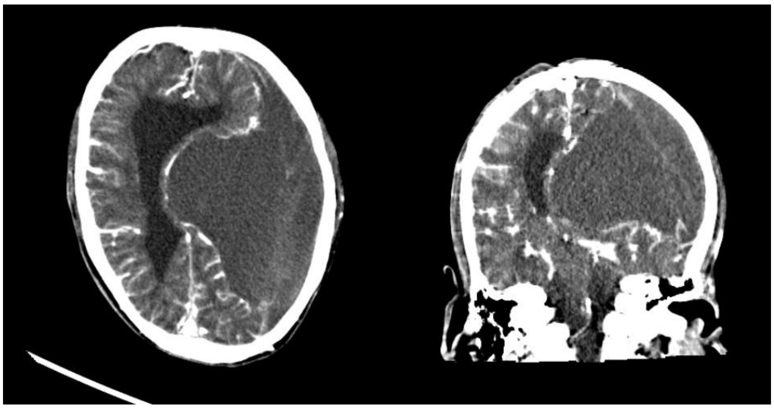

Figure 1. Preoperative CT scan of the 1st surgery revealed isodense subdural hematoma at the left hemisphere with three compartments separated by neomembranes

1st surgery: Because the subdural hematoma was multi-layered, a small craniotomy was placed and the dura was opened. Under direct visualization, the hematoma layers were fenestrated but the inner membrane over the cerebral cortex was left untouched. A 27 gauge needle was inserted in the shunt valve. Artificial CSF (Artcereb®, Otsuka Pharmaceutical, Tokyo, Japan) was slowly injected while the distal shunt catheter was pressed through the scalp to prevent the fluid flow to the distal side. As the fluid infused, the cerebral cortex gradually came up to the bone window. Nearly 200 ml of artificial CSF infusion enabled the brain re-expand close to the dura.

A CT scan taken immediately after the surgery showed satisfactory re-expansion of the cerebral mantle (Figure 2). However, subdural fluid accumulation recurred within a week (Figure 3). It was speculated that the anti-siphon function of the valve was insufficient. Second surgery was planned a week after the first one together with the fluid injection for cerebral re-expansion again to drain the subdural fluid.

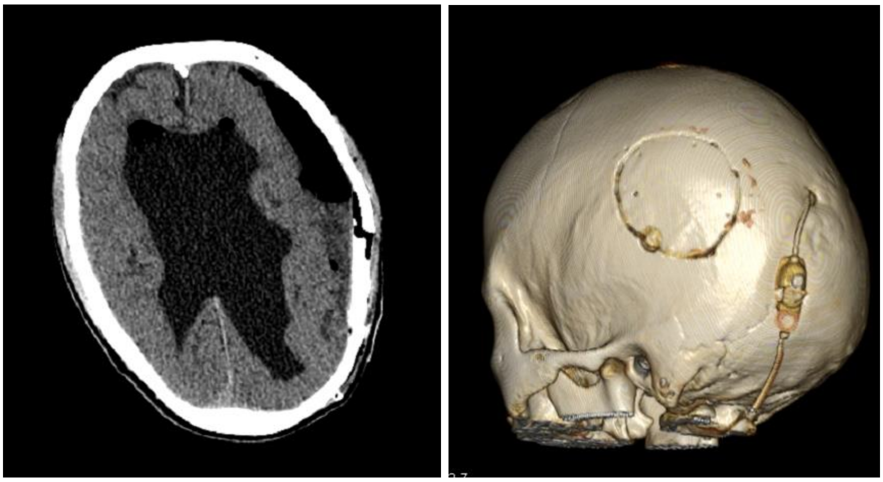

Figure 2. CT scan after the first surgery of intraventricular fluid injection and subdural fluid drainage with craniotomy.

Figure 3. CT scan before the 2nd surgery showed recurrence of subdural fluid collection

2nd surgery: The same skin incision and craniotomy were performed. After dural opening, cerebral re-expansion was obtained by the same procedure with the 1st surgery.

The volume of artificial CSF infusion was 120 ml. Then, the shunt valve was changed to a new programmable valve with different type of siphon guard system. Postoperative CT scan again demonstrated satisfactory re-expansion of the brain (Figure 4).

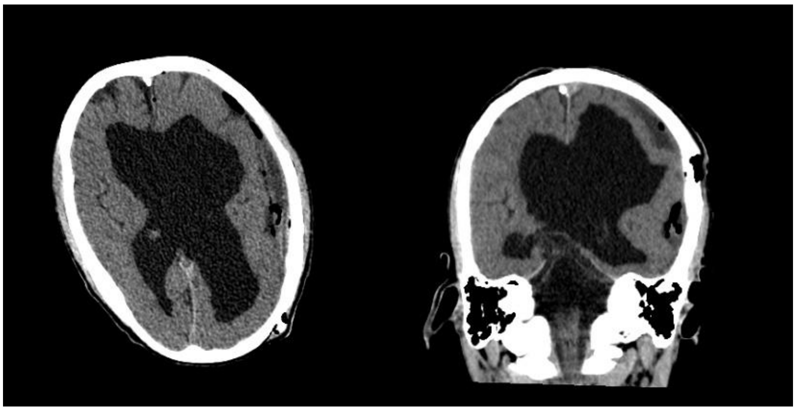

Figure 4. CT scan image immediately after the second operation. The same technique was applied with the change of shunt valve. The brain has expanded and most of the subdural fluid were drained by a single surgery.

The patient suffered shunt infection later caused by CSF leakage from the wound and one more shunt revision was required. However, no subdural fluid collection has recurred since the second surgery. The valve pressure was adjusted from the initial 80 mm H_2O to 120 mm H_2O during the clinical course. The latest CT scan taken 3 months after the last surgery showed stable condition in terms of both subdural fluid collection and hydrocephalus (Figure 5).

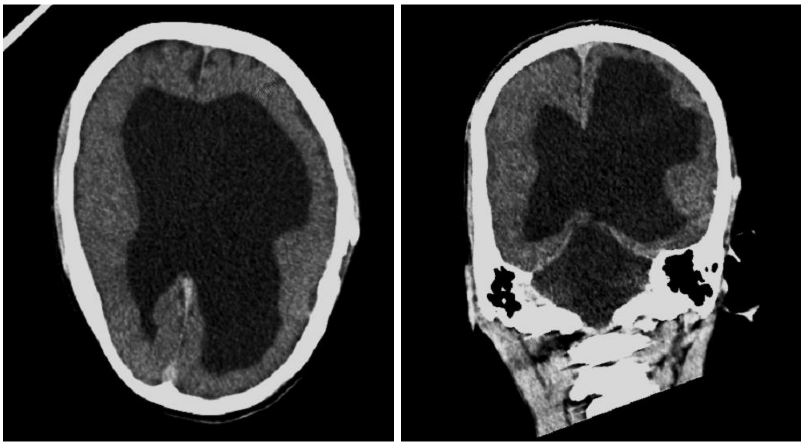

Figure 5. Control CT scan 3 months after the second surgery showed solution of the intractable subdural fluid collection caused by the VP shunt overdrainage.

Discussion

Selected literature review of the clinical course of patients with ventricular shunts for hydrocephalus shows that the effects of CSF overdrainage are subdural hygroma, craniosynostosis, slit ventricle and slit ventricle syndrome, low intracranial pressure syndrome and so on. These occur sequentially at different age groups. The approximate averages of these incidences were 10 – 12%, and time of occurrence after the first shunt was average about 6.5 years [8].

CSF overdrainage occurs due to an improperly set shunt valve or to siphoning of CSF caused by gravity when the child is upright, resulting in subatmospheric intracranial pressure and ventricular prolapse. It could lead to develop subdural fluid collection. Large subdural fluid collection which require surgical intervention can develops after overly vigorous and rapid drainage of enlarged ventricles [2][9].

Yoon et al in 2012 reported a series cases of 104 patients who underwent CSF diversion surgery using programmable valve for hydrocephalus and reported 58 (55.8%) patients developed subdural hematoma after VP shunt. Among them, 5 patients (8.6%) had symptoms caused by subdural hematoma [5].

While some subdural fluid collections are benign and can resolve spontaneously, others may grow to cause significant mass effect and neurologic compromise such as seizures and macrocephaly [5]. Changing the shunt valve with anti-siphon devices can be used to prevent recurrence of subdural fluid collections [7]. If the patient had already installed with a programmable valve, then by increasing the valve pressure will help to prevent the occurrence of subdural fluid collection [10].

Significant mass, especially if the thickness of hematoma is more than 7 mm with the presence of symptoms such as increased intracranial pressure, macrocrania, hemiparesis, seizure, mental deterioration indicates the need of immediate surgical mass removal [11]. Treatments for subdural fluid collections in children remains controversial. Repeated subdural taps have been shown to be inefficient. Reportedly, with as many as 42% patients required further treatments and a high rate of infectious complications [12].

Variety of surgical procedures have been applied for the treatment of subdural fluid collection. Cho et al, reported a series of 25 patients with pediatric subdural hygromas. The result showed 4 aspirations (success rate 50%), 22 subdural drainage (success rate 59%) and 13 SP shunt (success rate 69 %). External drainage for non-traumatic chronic subdural hematoma has been reported with a success rate of 60% - 95%, but the drainage must be maintained for a long period (median 6-15 days) and the risk of infection remains [13][14]. Some authors advocated the combined use of minicraniotomy for hematoma removal and external drainage with success rate of 87% [15].

Blauwblomme et al, reported a series of 18 patients of non-traumatic chronic subdural hematomas treated with subdural-subgaleal shunts in 2015. The result have a success rate of 78%, but the drawback of this procedure is the patients need to keep horizontally position during the postoperative period [6].

Subduroperitoneal (SP) shunt studies have a success rate of 75% - 90%, with the main advantages are a short period of hospitalization and lower infection rate[9][16][17]. Even though SP shunts have the highest success rate, SP shunt installation can lead to new risks of complications which are common for the CSF shunt surgery [18][19].

In our case report, we applied a novel surgical technique. It constitute two parts: injection of fluid into the ventricle and drain the subdural fluid through a craniotomy. Subdural fluid is drained through a small craniotomy while injecting artificial CSF retrogradely from the shunt valve so that the collapsed brain mantle can expand immediately. The fluid injection speed was controlled about 10 ml/minute. As the brain mantle re-expanded, the elevated cortex pushes the subdural fluid drained out from the craniotomy. The procedure was first reported by Morota in his description of “smart shunt” with the use of burr hole and normal saline as the intraventricular injection agent [20]. In this specific case, the subdural fluid formed multilayered hematoma. A small craniotomy, instead of burr hole was required for fenestration of the layered membrane [15]. The idea of fluid infusion came from a punctured ball being re-expanded by air pump [20]. This “fluid infusion” technique is expected to maximize the chance of brain re-expansion and to drain subdural fluid together at the single surgical session with immediate effect. The new technique is expected to contribute shortened hospital stay, to avoid additional surgeries for complicated subdural fluid collection and reduced the risk of infection from external drainage procedure and further complication from SP shunt. It should be reminded that the “fluid infusion” technique is the procedure to re-expand the collapsed brain in a single surgical setting with immediate effect. However, to maintain the re-expanded brain condition, additional procedure such as adjustment of the shunt valve pressure, shunt valve exchange to a programmable one or attachment of an anti-siphon device would be required.

As far as we know, this is the first case report using the novel “fluid infusion” technique. It should also be reminded that there have been no studies about safety of retrograde fluid infusion in the ventricle. Cerebral re-expansion in relatively short time may lead to unexpected complications. Nevertheless, we believe this technique can bring potentially great impact for the treatment of symptomatic subdural fluid collection associated with CSF overdrainage after VP shunt.

Conclusion

Intraventricular fluid injection as a treatment of symptomatic subdural fluid collection after VP shunt overdrainage was reported. This novel "fluid injection" technique has advantages over the current surgical treatment. Further studies and case accumulation are necessary to conclude its clinical safety and efficacy.

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