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RESEARCH

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Subdural collection after transcortical approach for pediatric brain tumors; avoidance, consequence and solutions

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Abstract

Introduction: Subdural collections, following brain surgeries in pediatrics, are common and unfortunately not always easily treated; especially in huge parenchymal tumors, intraventricular tumors and paraventricular tumors. Different approaches for prevention and treatment of theses subdural collections have been discussed by several studies, but till now no solid consensus has been reached. One of these approaches is to approximate incised cortical edges by suturing the pia, use of fibrin adhesive glue and subsequent Ringer inflation. The aim of our study is to avoid cortical mantle collapse and to prevent the development of progressive pressurizing subdural fluid collections.

Patients and methods: This study included 12 pediatric cases operated for large sized brain tumors between 2014 and 2019, in the department of Pediatric Neurosurgery at Alexandria University. All cases were operated via transcortical approach. Patients were followed prospectively for postoperative complications including postoperative subdural collections. In all patients, gel foam and fibrin glue on the cortical and ependymal edges, with suture approximation of the cortical edges and subsequent Ringer lactate inflation in the residual cavity were routinely done.

Results: With the consecutive follow-up images, six cases (50%) showed persistent subdural collection following tumor resection. Three cases had 5–6 mm asymptomatic subdural collection thickness that resolved within 3 to 6 months, and the rest three cases showed more than 7 mm thickness subdural collection. In these 3/12 (25%) cases patients had symptomatic and progressive increase in the subdural fluid collections. A subdural-peritoneal shunt was necessary only for 1 patient (8%). After finishing his adjuvant therapy, it was possible to remove the subdural-peritoneal shunt. While in the other 2 patients, the subdural collection was managed surgically with just a burr hole evacuation. The clinical manifestations resolved postoperatively but complete resolution of these 2 subdural collections occurred within 7 and 9 months.

Conclusion: The use of sutures and fibrin adhesive to seal surgical defects with inflation of the residual cavity with Ringer lactate solution might decrease the development of subdural fluid collections, through avoiding the cortical mantle collapse.

Keywords: Fibrin glue, Large pediatric brain tumor, Paraventricular tumor, Subdural fluid collection, Transcortical approach

Introduction

Subdural fluid collections commonly develop following surgery of large sized parenchymal tumors, intraventricular and paraventricular pediatric brain tumors. Their management is still controversial [1, 2].

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Occasionally the subdural fluid collections compress the underlying brain cortex producing effect on the brain, which manifest clinically. Postoperatively subdural collection less than 7 mm thickness usually be asymptomatic without any complain, while thickness more than 7 mm with progressive increase in the subdural fluid collection, patients show signs of increase intracranial pressure, and may exert vomiting, convulsions, irritability, failure to thrive, or continuous crying, up to disturbed level of consciousness [1].

Surgical intervention is indicated when there is progressive increase in the size of the fluid collection [3].

Different theories have been proposed for the expansion of these subdural fluid collections. It may be attributed to the postoperative escape of CSF (cerebrospinal fluid) into the subdural space through a possible ball–valve mechanism at the level of the cortical defect associated with CSF pulsation, the presence of untreated preoperative hydrocephalus, younger age as well as impaired CSF absorption at the site of the corticectomy. The described incidence of subdural collections after craniotomy in several series is relatively high, especially in pediatric ventricular and para-ventricular tumors. Approximately 10% of these collections require further surgical treatment [4].

Several techniques have been described in order to avoid postoperative subdural fluid collection as well as its treatment, firstly, to avoid such event, usually surgeon needs to detect the presence of any pressurizing hydrocephalus prior to tumor removal, and plan whether to insert a ventriculo-peritoneal shunt or not, also reducing the size of cortical incision. If the ventricular wall was opened intraoperatively, authors stated to use gel foam and fibrin adhesive on the ependymal defects. The aid of warm Ringer solution which leads to inflation of the brain after tumor removal was recommended in several studies, however sealing of the corticotomy using fibrin adhesive glue, then approximating the pial using microsutures over Gelfoam, thus avoiding the formation of a wide subdural space [1, 5].

In literature different methods was mentioned to treat the formed collection whether by insertion of a temporary external drain, and repeated lumbar taps, which have higher infection rate, or insertion of a subdural-peritoneal shunt, others preferred to manage the subdural collection by burr hole evacuation after opening of the dura. Furthermore; some researchers stated that these collections can resolve spontaneously without surgical intervention. Unfortunately, till this day there has been no standard treatment in the management of such collections [1].

The aim of our study is to avoid cortical mantle collapse and to prevent the development of progressive pressurizing subdural fluid collections.

Patients and methods

This study is a retrospective study reporting on twelve consecutive pediatric patients admitted to the department of Pediatric Neurosurgery at Alexandria University and presenting with large parenchymal tumors and intraventricular brain tumors were enrolled in this study between 2014 and 2019. Full imaging studies were done preoperatively to detect the extent of the brain tumors and the presence of preoperative hydrocephalus. These patients underwent surgery for resection of these large parenchymal tumors and intraventricular tumors through transcortical approach. Patients were followed up for postoperative complications including postoperative subdural collections and any subdural collection was reported. Furthermore, the detailed management and outcome of these collections were recorded.

Closure of transcortical approach

After safe maximal resection of the tumor and safe hemostasis. We started closing the ventricular ependymal defect then the cortical incision after.

First, gel foam and fibrin adhesive were applied to seal the ventricular ependymal defect. Fibrin glue (Tisseel® fibrin sealant, Baxter BioSurgery, Vienna, Austria frozen prefilled syringes) was previously prepared according to the producer's prescribing information. Fibrin glue was slowly applied, where it usually adheres to the edges of the ventricular ependymal defect, resulting in a watertight seal. After a 3-min wait in order to allow polymerization of the first layer, a second layer of glue was applied above the first layer. The cavity was slowly filled with warm (35 °C) Ringer lactate to avoid the collapse of the cortical mantle.

Finally, after inflating the cavity with Ringer lactate solution, the boundaries of the corticotomy were gently approached by the aid of a spatula while approximating the pia edges over another piece of Gelfoam. The pial edges were sealed by fibrin adhesive over the Gelfoam, then suturing the pial edges using micro-sutures (Fig. 1). We suggested approximately 12 min were required to close the corticotomy defect.

A subdural space of less than 5 mm in actual thickness calculated from the initial postoperative computerized tomography (CT) scan performed within the first 24 h was not considered as an indicator for a significant subdural fluid collection. However, repeated follow-up CT scans were requested if the thickness was more than

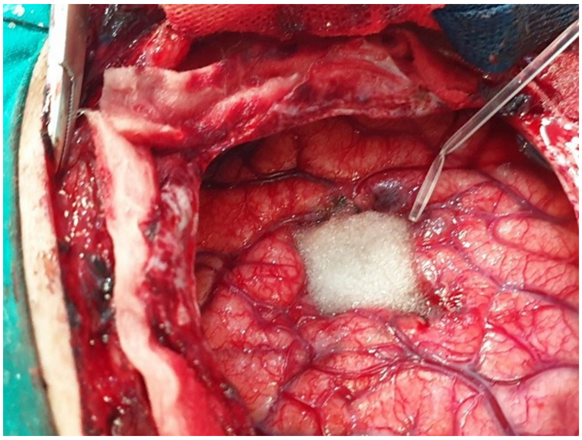

Fig. 1 Sealing fibrin adhesive glue at the sits of cortical incision

5 mm in order to monitor any progressive increase in the thickness of the developing subdural collection. Surgical management of these collections (more than 5 mm) was indicated if any of the patients showed any focal neurological deficits or neurological deterioration.

Follow-up magnetic resonance images were obtained at intervals of 2 months, 6 months, 1 year postoperatively and then yearly thereafter.

Ethical approval

An informed written consent was obtained from all legal guardians of the pediatric patients before enrollment in the study. The study was approved by the local ethics committee of Faculty of Medicine, Alexandria University.

Results

This study enrolled 12 pediatric cases for operations, 8 of them were males, with a median age of 6.5 years. Transcortical approach was used in all cases; frontal transcortical approach was used in 9 patients, parietal approach in 2 cases and occipital transcortical approach in a single case. The median follow-up was 8.8 months, ranging from 3 to 26 months.

Pathologically, 5 patients were diagnosed with pilocytic astrocytoma, 3 patients with primitive neuro-ectodermal tumors (PNET), 2 patients with dysembryoplastic neuroepithelial tumors (DNET), 1 patient with Choroid plexus carcinoma and 1 patient with Choroid plexus papilloma.

In all our 12 cases the tumor cavity created after tumor resection was inflated using Ringer lactate, then the pial surfaces were approximated and sutured closed over a piece of Gelfoam using micro-sutures, Fibrin glue was used to adhere the edges of the cortical defect with the piece of Gelfoam resulting in a watertight seal.

Three cases out of our 12 cases the ventricles were opened during surgery, in these 3 cases: first, gel foam was used to seal the ependymal defect and fibrin adhesive layer was then applied over the gel foam to close the ependymal edges. Second the cavity was inflated with Ringer lactate and the pial surface was sutured and at last gel foam was applied on the cortical incision and reinforced with a layer of fibrin glue.

All cases had follow-up CT within the first 24 h of surgery. All cases showed collapsed brain and widening of the subdural space immediate postoperatively. However, with the consecutive follow-up images, six cases (50%) showed persistent subdural collection. Three cases had 5–6 mm asymptomatic subdural collection thickness that resolved within 3 to 6 months, and the rest three cases showed more than 7 mm thickness subdural collection. In the 3/12 (25%) cases where the subdural fluid collection was observed to be more than 7 mm thickness, patients had symptomatic and progressive increase in the subdural fluid collections. Subdural-peritoneal shunt was inserted for only 1 patient (8%). After the completion of the adjuvant therapy, and decreasing of the subdural collection, it was possible to remove the subdural-peritoneal shunt after 6 months.

While in the other 2 patients, the subdural collection was managed surgically with just a burr hole evacuation, opening the dura and communicating the subdural space to the subgaleal space with a closed drainage system which was left for 3 days. The clinical manifestations resolved postoperatively but complete resolution of these 2 subdural collections occurred within 7 and 9 months.

The remaining other 6 patients had thin rim subdural fluid collections that disappeared or reduced spontaneously within 2 months' follow-up.

Five patients (41%) were complaining of convulsions preoperatively, no progression in frequency or severity postoperatively was challenged, and the remaining patients did not experience new seizures.

No postoperative infections were reported nor postoperative hydrocephalus developed. Where we didn't need any ventriculo-peritoneal shunts in all our cases.

Illustrated cases

Case 1

A 9 months old boy presented with vomiting, convulsions, irritability, failure to thrive, continuous crying and disturbed level of consciousness. Magnetic resonance imaging (MRI) revealed huge intraventricular space occupying lesion (SOL) and evolving hydrocephalus. Patient was prepared for immediate surgery. Transcortical approach was done. Gross total resection of the lesion was achieved. Postoperatively the patient developed bilateral large subdural hygroma more on the right side, a temporary subdural-peritoneal shunt was inserted to drain the accumulated CSF and decrease the pressurizing subdural collection on the brain. (Fig. 2).

Case 2

Two years old boy presented with vomiting, irritability, failure to thrive. CT and MRI brain revealed intraventricular tumor. Frontal transcortical approach was done. Gross total resection of the lesion was achieved. Follow-up MRI 2 months after surgery revealed mild increase in the left subdural collection without any neurological manifestations (Fig. 3).

Discussion

The described incidence of subdural collections after craniotomy in aneurysm surgery, ventricular drainage, plexectomy, and shunting procedures in several series is relatively high, ranging from 17 to 52%, particularly in pediatric patients [6, 7]. However the removal of intra- and paraventricular tumors in pediatric patients through transcortical approaches, the incidence was reported to reach 40%, although most of them do not necessitate a treatment [1].

According to Mirone et al. [8] they observed (29%) 5 patients with a 5-mm-thick subdural fluid collection after removal of intra- and paraventricular tumors in pediatric patients through transcortical approaches, (17%) 3 patients underwent surgery for symptomatic or progressive subdural fluid collections.

Delalande et al. [9] stated that approximately 10% of these subdural collections require further surgical management.

Morita and Kelly [10] they suggested a strict follow-up by CT scan after transcortical intraventricular surgeries every 2 weeks, and to evacuate any progressive or symptomatic subdural fluid collection.

In our results 50% of our cases showed postoperative subdural collection, 25% of the cases were resolved spontaneously, and the other 25% of the cases showed symptomatic and progressive increase in the subdural fluid collections, which required surgical intervention.

Several techniques have been described to prevent the development of postoperative subdural fluid collection. However, till this day, experts in this field have yet to reach a consensus for the optimal preventive and therapeutic techniques for the management of such collections [1].

One of the most important techniques mentioned in the literature to prevent postoperative subdural collections is reducing the size of cortical incision, using warm Ringer solution which leads to inflation of the brain, then sealing the corticotomy by pial sutures and fibrin glue over a Gelfoam piece, to decrease the potential subdural space thus avoiding the formation of a wide subdural space [1, 5, 11].

A series of 11 choroid plexus cancers were reported by Boyd and Steinbok. They advised suturing the pia over a piece of Gel Foam after filling the ventricle with Ringer lactate solution, to avoid subdural fluid accumulation [12].

Al-Yamany et al. [1] suggested closing the cortical incision with fibrin glue because of none of their 25 patients developed symptomatic fluid collections.

Subdural collection that are 7 mm or less on CT scan could be managed conservatively, and have a high chance for complete spontaneous resolution [13]. In cases of symptomatic subdural collection some studies recommended repeated subdural taps over a period of 2 months for its management [14]. However, according to Aoki [15] 40% of cases managed by repeated subdural taps fail in controlling the size of the subdural collections, and other forms of surgical intervention are required [15]. In the current study repeated taps were not tried for fear of infection, but we successfully managed 2 cases by burr hole evacuation without further complications.

According to Brotchi and Bonnal [16], external drainage of the subdural space has been employed, but has the risk of infective and mechanical complications of the external drains, especially in very young children [16]. In our study we didn't use external drains to avoid infection.

The easiest and most effective method of managing the subdural collections seems to be the surgical insertion of a subdural-peritoneal shunt. It is usually associated with a very high success rate reaching up to 80% and sometimes 100% in controlling subdural collections. Furthermore, a single shunt could control bilateral collections [17].

Mirone et al. [8] reported that it was possible to remove the subduro-peritoneal shunt in all their patients, after the patients finished their adjuvant therapy, because of the disappearance of the subdural fluid collections.

In Boyd and Steinbok study two patients experienced symptomatic subdural collections, necessitating the insertion of subdural shunts in both cases [12].

The controversy of the removal of the subdural-peritoneal shunt needed for managing the postoperative subdural collections, arises from the exposure of the patient to a second surgery with all its hazards. In this study, we needed to insert subduro-peritoneal shunt in a single case and we removed it after 6 months following the complete drainage of the collection. Leaving the shunt in place without removing it after complete drainage of the collection is also seen as a perfectly acceptable course.

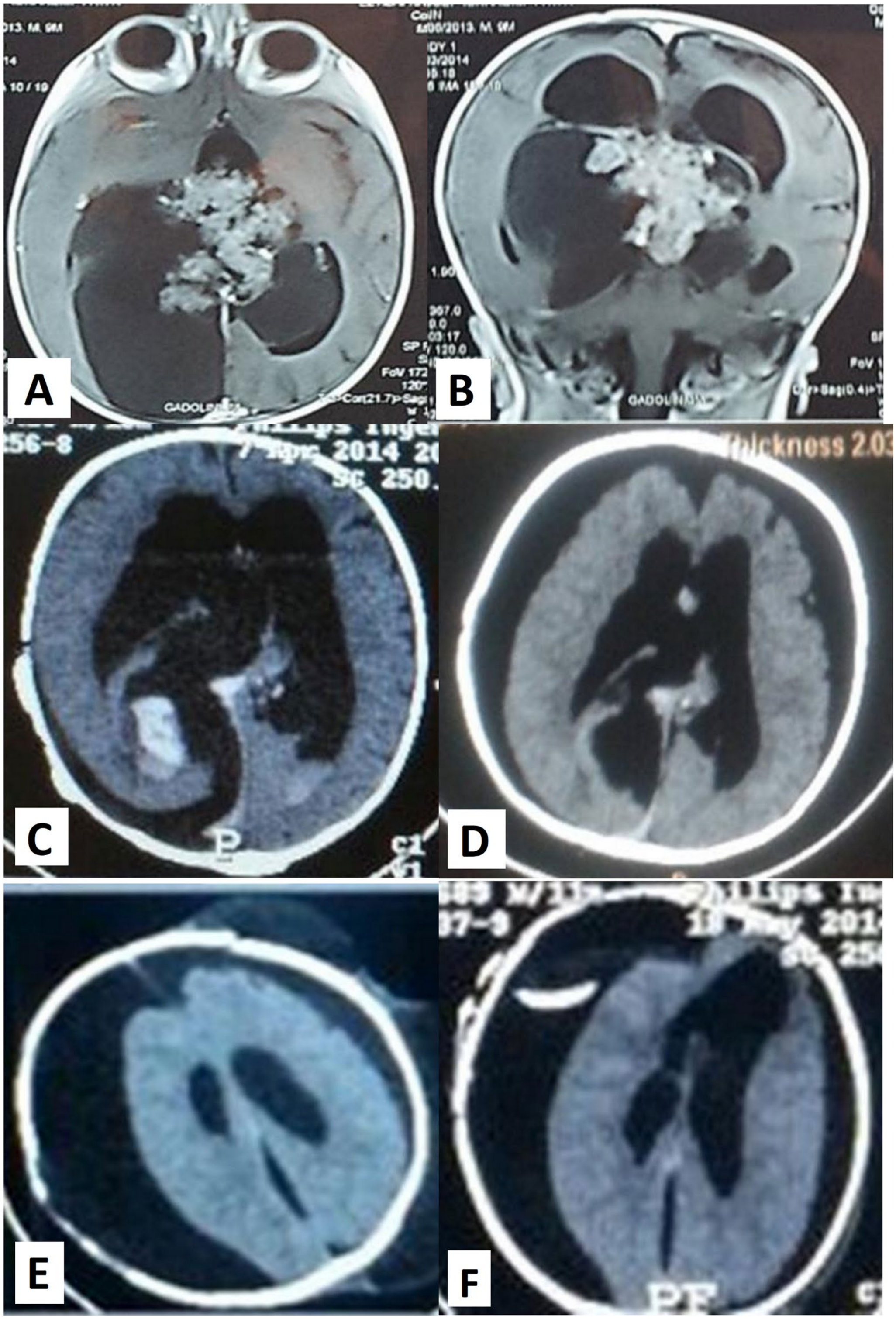

Fig. 2 **a, b** Contrast enhanced MRI brain T1 films (axial and coronal views) showing huge choroid plexus carcinoma with developing hydrocephalus. **c** Immediate postoperative CT brain reveals a well removed intraventricular tumor with minimal right subdural collection. **d**, **e** Seven days postoperative CT brain reveals increasing of the subdural collection bilaterally and more on the right side. We can notice a vanishing of the right sulci and gyri of the right hemisphere. **f** Postoperative CT brain after insertion of the subdural-peritoneal shunt

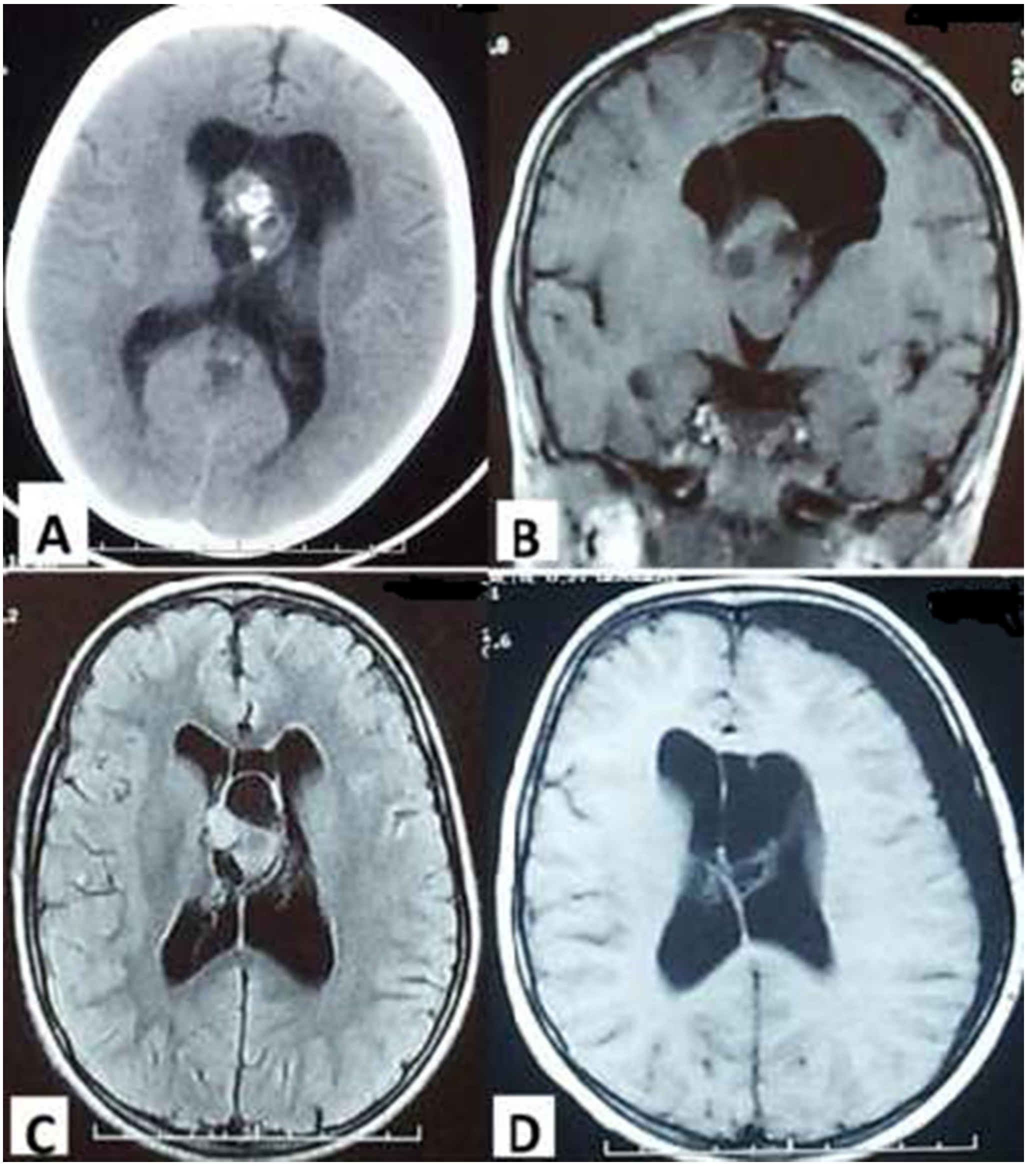

Fig. 3 **a** Contrast enhanced CT brain (axial view) showing intraventricular tumor with developing hydrocephalus. **b**, **c** Contrast enhanced MRI brain T1 films (axial and coronal views) showing cystic well enhanced intraventricular lesion with developing hydrocephalus. **d** Follow-up MRI 2 months after surgery demonstrating well removed intraventricular mass with mild asymptomatic increase in the subdural fluid

Our results showed relatively high percentages, since our study only discussed the removal of pediatric tumors through transcortical approaches and did not include any other age group or approaches. Also due to the small number of patients in our study compared to other published studies discussing similar topics.

Conclusions

Using sutures and fibrin adhesive to seal surgical defect with inflation of the residual cavity with Ringer lactate solution might decrease the development of subdural fluid collections, through avoiding the cortical mantle collapse. However, if subdural collection developed, small collections less than 7 mm could be managed conservatively while large symptomatic collections should be managed surgically with burr hole evacuation or subdural peritoneal shunt insertion.

Abbreviations

CSF: Cerebrospinal fluid; CT: Computerized tomography; DNET: Dysembryoplastic neuroepithelial tumors; Fig: Figure; mm: Millimeter; MRI: Magnetic resonance imaging (MRI); PNET: Primitive neuro-ectodermal tumors; SOL: Space occupying lesion.

Acknowledgments
Not applicable.

Author contributions
IS designed the study and wrote the initial manuscript. MAE assisted in the final preparation of the manuscript. AEE has participated in the final revision of the manuscript and added two more cases operated by the same technique. All authors have contributed to this study and approved the final version of the manuscript.

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Availability of data and materials
All data used are available from the corresponding author on request.

Declarations

Ethics approval and consent to participate
An approval from the research ethics committee of the Faculty of Medicine, Alexandria University [serial number 0304362], was obtained in July 2019. Furthermore, being a retrospective study, patients' consents for participation was not applicable.

Consent for publication
Not applicable.

Competing interests
The authors had no competing interest to report.

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