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Prise en charge de l'hydrocéphalie dans les tumeurs métastatiques de la fosse cérébrale postérieure chez l'enfant

Surgical management of hydrocephalus caused by metastatic tumors of the posterior fossa in children

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Liste des abréviations

AUH	Angers University Hospital
CSF	Cerebro Spinal Fluid
DIPG	Diffuse Intrinsic Pontine Gliomas
ETV	Endoscopic Third Ventriculostomy
PFT	Posterior Fossa Tumors
PVD	Pre-resectional Ventricular Drainage
RUH	Rennes University Hospital
VPS	Ventriculo Peritoneal Shunt

Sommaire

Surgical management of hydrocephalus caused by metastatic tumors of the posterior fossa in children

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ABSTRACT

Object. Surgical management of hydrocephalus in metastatic tumors of the posterior fossa in children must be effective. Indeed, any reoperation related to hydrocephalus may be a life-threatening situation notably if neoadjuvant chemotherapy is mandatory before surgical removal. This study tried to retrospectively examine the effectiveness of the different shunt procedures used in these children and aimed to identify factors associated with shunt failure.

Methods. From January 2005 to December 2015, 29 children came to our institutions for hydrocephalus related to a metastatic posterior fossa tumor. All the children had signs of raised intracranial pressure caused by hydrocephalus and underwent a shunt procedure. Shunt failure was defined as the necessity to perform any subsequent shunt procedure within the 6 months following admission. Surgical complications related to hydrocephalus, length of stay in hospital, initiation of oncologic treatment, and survival including follow-up to December 2015, or time of death, were recorded.

Results. Four patients (14%) were operated by ventriculo-peritoneal shunt (VPS), 18 patients (62%) underwent endoscopic third ventriculostomy (ETV) and 7 (24%) patients had a pre-resectional ventricular drainage (PVD) before or during surgical removal of the primitive tumor. No difference was observed on the outcomes between the three groups. However, high rates of shunt failure (52%) and of surgical complications (31%) were reported. The mean follow-up time in the study population was 27,2 months (range 3 - 90). A significant decreased in cumulative survival (p = 0,0065) was observed in children who had a shunt failure. 56% of patients operated with ETV had shunt failure. These patients were significantly younger (3,4 versus 6,3 p = 0,041). The presence of cerebro-spinal fluid (CSF) metastatic cells was significantly associated with ETV failure (OR 16,33 [95% CI 1,35-197,77], p = 0,028). Patients operated first by VPS first started their oncologic treatment earlier and after shunt failure a VPS was done in 73% of cases. Long-term follow up of children who underwent a VPS showed only two cases of early dysfunction. No case of dissemination and extracranial metastasis through the catheter was reported.

Conclusions. CSF metastatic cells may cause impaired CSF absorption that could lead to hydrocephalus. Thus, in metastatic posterior fossa tumors, the mechanism of hydrocephalus may not only be obstructive. This hypothesis may explain the lower efficiency of ETV and PVD for the management of hydrocephalus in metastatic posterior fossa tumors in children. VPS allows us to start the oncologic treatment earlier and could be a good option in first intention or after ETV failure in these metastatic cases.

INTRODUCTION

The majority of pediatric brain tumors in children are located in the posterior fossa.[23,36,44] Given their location, almost 70 to 90 per cent of children with posterior fossa tumors (PFT) have associated hydrocephalus.[16,23,32,36,37,41,47,54] Intracranial hypertension caused by hydrocephalus often reveals PFT.[13,24,54] In most cases, it is therefore an emergency situation that requires an immediate therapeutic response to control the intracranial pressure.[14,24,41]

Metastatic PFT at presentation are not so infrequent and represent between 7 and 17% of children with PFT.[44,46] This proportion may reach as much as 30% of newly diagnosed medulloblastomas which is the most common malignant pediatric brain tumor.[17,50] These patients require specific care because, in cases of metastatic medulloblastomas at presentation, neoadjuvant or immediate postoperative chemotherapy is mandatory.[18,26,27,57] Furthermore, the clinical presentation and outcomes of these children are different according to the location of the metastases.[17] The surgical management of hydrocephalus in metastatic PFT in children is therefore a challenge to control intracranial pressure without delaying the histological diagnosis and the oncologic treatment.[27] Indeed, any reoperation related to shunt failure represents a life-threatening situation during bone marrow depression.[46]

Endoscopic third ventriculostomy (ETV) is the most frequently used shunt procedure in children with PFT because of the obstructive mechanism of hydrocephalus. [6,11,12,19,45,46] Indeed, ETV seems to be a more physiological and anatomical diversion pathway for CSF in theses cases.[6] However, according to recent reviews,[13,37] we think that metastatic cells may cause impaired CSF absorption within the peripheral subarachnoid spaces. This dysfunction may result in a communicating pattern of hydrocephalus in metastatic PFT. Thus, because the success of ETV depends on an intact absorption of CSF,[51] we think there is probably a higher risk of ETV failure in these cases.

Ventriculo-peritoneal shunt (VPS) is an alternative shunt procedure in PFT[1] but includes the theoretical risk of spreading through the catheter[2,3,5,9,22,29,30,38,39,48] and the well-known problems associated with shunt insertion.[6,11,12,19] Lastly, a ventricular drainage before or during surgical removal of the primitive tumor can also be used to control hydrocephalus in PFT.[43] But this strategy is limited by a high risk of postresection hydrocephalus related to the presence of metastases.[13,37,44]

To date, however, no specific studies have been conducted on the surgical management of hydrocephalus in children with metastatic PFT at presentation. This study tried to retrospectively examine the effectiveness of the different shunt procedures used in these children and aimed to identify factors associated with shunt failure. The purpose of this study was to determine which shunt procedure is the most appropriate according to the clinical presentation of these particular cases.

PATIENTS AND METHODS

Study population

The study has been approved by the ethic board at both participating centers. All patients included came from the Pays de la Loire and Bretagne regions in western France (more than 6.9 million people in 2013) for which Angers University Hospital (AUH) and Rennes University Hospital (RUH) are respectively reference centers for pediatric neurosurgery.

The medical records of 235 consecutive pediatric patients, younger than 18 years of age, who were admitted to AUH and to RUH, from January 2005 to December 2015, with newly diagnosed posterior fossa tumor were retrospectively reviewed including follow-up to December 2015, or time of death.

Benign tumors of the posterior fossa and diffuse intrinsic pontine gliomas (DIPG) were excluded in order to compare homogeneous patients with a metastatic malignant posterior fossa tumor involving the cerebellum and/or the fourth ventricle. 92 children had a malignant posterior fossa tumor and eventually 29 children with metastatic spread and hydrocephalus at presentation were included (**Figure 1**).

Clinical data

Table 1 shows the clinical characteristics of the 29 children. A full history of these patients was taken including clinical and radiographic data. The majority of them were male (65.5%) and the mean age was 5.1 years (range 2 months - 11.4 years).

All the children in this study had signs of intracranial hypertension caused by hydrocephalus. Lethargy, considered as a Glasgow Coma Scale score of less than 14 documented at presentation, was present in five patients (17.2%). In five cases (17.2%), papilledema was recorded after preoperative retinal examination performed by an ophthalmologist. Symptoms lasted less than one month in the majority (62.0%) of the patients.

Hydrocephalus was present in all cases based on a standardized ratio (Evans Ratio or Ventricular Index) higher than 0.4. Evans Ratio was defined on a preoperative cranial CT (computed tomography) scan as the proportion between the maximum width of the lateral ventricles at the frontal horns and the largest transverse diameter of the skull's internal table. A cranio-spinal magnetic resonance imaging (MRI) was performed in all cases. These exams and their radiology reports were reviewed. The presence of a transependymal edema was noted in 22 cases (75.8%) with increased periventricular T2 signal on FLAIR MR images.

Tumor characteristics

All the children had a primitive posterior fossa tumor with metastatic spread at presentation including both diffuse leptomeningeal spread and/or secondary solid disease (**Table 2**). The primitive tumor always developed in the fourth ventricle and also extended in the ponto-cerebellar angle in 6 cases (20.6%). The mean size of the primitive tumor was 44 ± 11.6 mm (range 14 - 63).

Based on the neuroradiologists' reports, distant metastases were defined as an abnormal deposit, with gadolinium enhancement measurable in two dimensions, and were recorded in three categories according to their anatomic characteristics. Supratentorial, infratentorial and spinal metastases were thus found in 14 (48.3%), 16 (55.2%) and 16 (55.2%) patients respectively. Diffuse leptomeningeal spread was notified in 13 cases (44.8%) with non-measurable in two dimensions increased contrast enhancement of the posterior fossa meninges in T1-weighted, contrast-enhanced MR images.

The presence of metastatic cells in the cerebrospinal fluid (CSF) was requested for all the children in our study according to a common protocol. A postoperative lumbar puncture and CSF cytological culture were performed between the 7th and the 15th postoperative days.

Surgical management and outcomes

Surgical procedures described in this study were undertaken by pediatric neurosurgeons. Children were divided into three groups according to the shunt procedure performed (**Table 3**). Patients operated by ventriculo-peritoneal shunt (VPS) were included in the first group. Patients operated by endoscopic third ventriculostomy (ETV) formed the second group. Patients who underwent ventricular drainage before or during primitive tumor resection were placed in a third group called pre-resectional ventricular drainage (PVD).

The primary outcome measure was the incidence of shunt failure defined, in this study, as the necessity to perform any subsequent shunt procedure within the 6 months following admission. As observed in other studies,[23,44,50] this 6 months period was chosen to exclude shunt failure related to disease progression. Surgical complications exclusively related to the shunt procedure were reviewed. The length of stay in hospital was calculated from admission to the day when children returned home or were admitted to a rehabilitation centre. Hospital readmissions related to shunt failure were added. The initiation of oncologic treatment was recorded. Survival analysis, including long-term follow-up to December 2015, or time of death, was conducted in all children.

Statistical Analysis

The quantitative parameters were compared among the three groups of patients with a Student test or an analysis of variance (ANOVA) according to the number of groups for the normally distributed variables. For others variables, a Wilcoxon test was calculated when two groups were compared whereas a Kruskall-Wallis test was used in other cases. The qualitative parameters were compared among the three groups of patients with a $\chi 2$ test or with a Fischer exact test depending on workforces (**Table 3**).

The study of survival is represented by Kaplan-Meier survival analysis. A logrank test has been used to compare the occurrence of death depending on shunt failure in the study population (**Figure 2**).

In the second group (ETV group), factors associated with shunt failure were analyzed with univariate logistic regression. Multivariate logistic regression was conducted on these variables when univariate logistic regression was significant (**Table 4**). These analyses were not conducted in both other groups due to their small number of children.

RESULTS

Surgical management, histological diagnoses and CSF cultures

The first group included 4 patients (13.8%) operated by VPS first. A surgical biopsy was then carried out on a metastase. In two cases, a biopsy of a spinal metastase was done. In one case, a biopsy of the primitive tumour was realised. In the last case, a biospy of a third ventricular metastase was performed using endoscopic surgery.

The second group included 18 patients (62.1%) operated first by ETV. A surgical biopsy was undertaken on a spinal metastase and on a third ventricular metastase in two and one cases respectively. In the other cases, the diagnosis was made by a surgical approach of the primitive tumor. Out of these patients, the primitive tumor was surgically removed in 12 cases whereas a simple biopsy was conducted in three cases.

The third group included 7 patients (24.1%) who underwent PVD before primitive tumor removal. In 4 out of 7 cases, a ventricular catheter was placed in the occipital horn of the right lateral ventricle during primitive tumor resection and was then removed immediately. In the three last cases, an external ventricular drainage was placed in the frontal horn of the right lateral ventricle before posterior fossa surgery and then removed on average 8.3 days after the resection (range 7 - 9).

Histological diagnoses revealed 26 medulloblastomas (89.7%) and 3 ependymomas (10.3%) whereas metastatic cells were found postoperatively in the CSF in nearly half the cases (48.3%). The three groups were comparable on these variables. Furthermore, there was no significant difference between the three groups on all clinical, radiographic, primitive tumor and metastatic spread characteristics described in Tables 1 and 2.

Outcomes

Table 3 shows the outcomes of the surgical management in the study population and in the three groups. The incidence of shunt failure in the study population was 51.7% (15/29) and was not significantly different in its distribution across the three groups ($p = 0.66$). One patient (25%) in the VPS group was reoperated because of a shunt infection, at 2 months postoperatively, with the same technique. Recurrence of hydrocephalus occurred

in 10 out 18 cases (55.5%) in the ETV group after an average time of 21.3 days postoperatively (range 2 - 81). In 8 cases a VPS was performed and in one case an ETV was redone. In one case a child required emergency posterior fossa surgery because he had altered consciousness 2 days after ETV. A pre-resectional ventricular drainage was necessary before primitive tumour removal in this case. 4 cases out of 7 (57.1%) were reoperated in the PVD group after an average time of 52.7 days postoperatively (range 1 - 161). VPS and ETV were each performed in two cases.

The mean length of hospital stay was not significantly different between the three groups ($p = 0.83$). All children with medulloblastomas received chemotherapy whereas children with ependymomas were treated with external radiotherapy except in one extreme case of ependymoma in a two-month old girl (ETV group). Neoadjuvant chemotherapy was administrated in the 10 cases for which a biopsy was initially performed. The primitive tumor was surgically removed after neoadjuvant treatment except in two cases (ETV group) for which a good response to therapy was observed. The oncologic treatment tended to start earlier in the VPS group as compared to the ETV and PVD groups but the difference was not statistically significant ($p = 0.12$).

The complication rate was particularly high in the study population (31%) and in the PVD group (42.9%) but not significantly different between the three groups ($p = 0.84$). 4 cases (13.8%) of infection with a positive bacteriological analysis were documented and required antibiotic therapy. One case (3.5%) of intraventricular haemorrahge was described on a postoperative CT scan in the ETV group. 6 patients (20.7%) had CSF leakage for which a wound dehiscence was observed. This complication involved especially patients from the ETV group and PVD groups with 16.7% (3/18) and 42.8% (3/7) respectively. Two cases (6.9%) of postoperative severe hyponatremia were found in the ETV group.

Survival analysis

The mean follow-up time in the study population was 27.2 months (range 3 - 90). At the end of follow-up, 16 children were alive. Survival analysis showed a decrease of cumulative survival in children who had shunt failure (**Figure 2**). The logrank test was highly significant ($p = 0.0065$) illustrating that the occurrence of shunt failure indicated a poor prognosis.

Factors associated with ETV failure

Table 4 summarizes the data obtained among the patients in the second group. As specified above, there were 18 patients (62.1%) treated first by ETV and, among them, 10 children (55.5%) had ETV failure requiring a second shunt procedure. In the univariate analysis, patients who had ETV failure were significantly younger (3.4 versus 6.3 years, p = 0.041). The presence of postoperative CSF metastatic cells was also significantly associated with ETV failure (p = 0.025). The multivariate analysis confirmed that younger age (OR 1.77 [95% CI 1.00-3.15], p = 0.05) and the presence of postoperative CSF metastatic cells (OR 16.33 [95% CI 1.35-197.77], p = 0.028) were significantly associated with ETV failure.

Other clinical characteristics summarized in Table 1, histological diagnoses as well as primitive tumor and metastatic spread characteristics described in Table 2 did not influence the risk of ETV failure. However, although not significant, all the children who had ETV failure were affected by at least two metastatic sites including supratentorial, infratentorial, spinal metastases or leptomeningeal spread (p = 0.06). Diagnosis management performed by ventricular, spinal biopsy or posterior fossa surgery had no impact on the outcomes. Direct primitive tumor removal did not affect the incidence of ETV failure (p = 0,64). Patients who had a successful ETV were treated earlier (23.4 versus 30) but the difference was not significant (p = 0.92).

Long-term follow up after VPS

14 children had VPS in first intention or after shunt failure. The mean follow-up for them was 14.8 months (range 3 - 32). During the follow-up, only two cases of VPS dysfunction were reported. No dysfunction or complications were observed thereafter. There were, in both cases, early dysfunctions that occurred on the 7th postoperative day and at 2 months postoperatively, because of shunt malposition and shunt infection respectively. In one case, the child passed away 11 months later as a result of disease progression. In the other case, the child is well 9 months following his admission.

DISCUSSION

Childhood metastatic PFT

Metastatic PFT at presentation are not infrequent with an incidence of 12.3% in our study (29/235) and up to 17% of children with PFT in the literature.[46] Approximately 30% of newly diagnosed childhood medulloblastomas have a disseminated disease.[17,50] Metastatic ependymomas at presentation are more uncommon and estimated between 10 to 30% of childhood ependymomas.[21] However, no studies have investigated specifically these particular cases and therefore epidemiological characteristics of metastatic PFT in children are missing. Given their location, hydrocephalus is often associated in children with PFT in almost 70 to 90% of cases[16,23,32,36,37,41,47,54] but its surgical management is still debated.[13,37,49] Hydrocephalus in metastatic PFT needs specific care to control intracranial pressure without delaying the histological diagnosis and the oncologic treatment.[27] Indeed, metastatic medulloblastomas at presentation require neoadjuvant or immediate postoperative chemotherapy.[18,26,27,57] Conversely, the management of metastatic ependymomas is based on surgical resection.[60] However, some studies[21,40] have reported the role of adjuvant conformal radiotherapy[21,40] and postoperative chemotherapy has already been used in children younger than 3 years.[28] Thus, surgical management of hydrocephalus in childhood metastatic PFT at presentation must be effective because any failure and reoperation may often be life-threatening if oncologic treatment has already begun.[46]

Approximately 52% of children included in our study had shunt failure and were reoperated. There was no significant difference in the incidence of shunt failure according to the shunt procedure performed ($p = 0.66$). This result shows that surgical management of hydrocephalus in children with metastatic PFT at presentation poses particular challenges. Furthermore, we have demonstrated that shunt failure indicates a poor prognosis with a significant decrease in cumulative survival in these children ($p = 0.0065$). We also noticed a high rate of shunt-related complications in 31% of children in our study highlighting their vulnerability. Our study is the first to examine the outcomes of the surgical management of hydrocephalus in children with metastatic PFT at presentation. Our results show that such data are of primary importance to determinate the most effective shunt procedure and factors associated with shunt failure in order to improve the management of these children.

ETV in childhood metastatic PFT

Most studies conducted on the surgical management of hydrocephalus in childhood PFT have shown the efficiency and safety of ETV.[6,11,12,19,45,46] Indeed, because of the obstructive mechanism of hydrocephalus in PFT, ETV is now widely used as a routine before[6,11,12,19,45,46] or after surgical removal in cases of postoperative hydrocephalus.[13,16,25,41,54–56] ETV is also used now in many different causes of communicating hydrocephalus in children such as posthemorrhagic[10] or infection[52] but its effectiveness in this particular mechanism of hydrocephalus is still be debated.[42,51] In the literature, two recent studies have performed 501[35] and 618[33] ETV in pediatric patients for various causes of hydrocephalus and have reported a global failure rate of 29% and 34% respectively. In our study referring exclusively to metastatic cases, 62% of the children underwent first ETV but 56% of them were reoperated. These observations suggest that ETV seems to be the first option in metastatic PFT but its efficiency is uncertain in these particular cases.

Factors associated with ETV failure were analyzed in order to understand this result. We have highlighted that CSF metastatic cells were significantly found in patients who had ETV failure ($p = 0.028$). As argued by other authors,[13,37] we think that CSF metastatic cells cause impaired CSF absorption and lead to a communicating hydrocephalus. This hypothesis is supported by the fact that, in our study, direct surgical removal of the primitive PFT did not affect the incidence of postoperative hydrocephalus after ETV ($p = 0.64$). Because success of ETV depends on an intact absorption of CSF,[51] this communicating mechanism could explain the high rate of ETV failure in these metastatic cases as reported by some authors.[6,45,54]

In our study, children who had ETV failure were significantly younger (3.4 versus 6.3, $p = 0.041$). This result has repeatedly been observed in other studies[15,33,35] and can be explained by the low capacity of CSF absorption by the Pacchioni granulation in young children.[4,20,31,58] In an interesting development, we observed that children who had no ETV failure were treated earlier (23 vs 30 days $p = 0.92$). Although not significant, this difference might be explained by the fact that chemotherapy eliminates CSF metastatic cells and could improve CSF absorption. Indeed, in our study, ETV was successfully done after shunt failure in three cases while adjuvant chemotherapy had already been administered.

There was a 27.8% rate of complications after ETV in our study. This rate is much higher than an overall complication rate of 8.5% observed in a recent review[7] and in most series reporting rates between 5 and 15%.[8]

This result is linked to the high rate of ETV failure in our study. Indeed CSF leakage is often the sign of early ETV failure[8] and infective complications are commonly related to CSF leakage.[8] Surgical complications observed after ETV in our study such as infection, hemorrhage, CSF leakage and hyponatremia have been already described in the literature.[8,34]

PVD and early posterior fossa surgery in childhood metastatic PFT

PVD including ventricular drainage before or during surgical removal is an alternative surgical management of hydrocephalus in PFT in children.[43] For most recent studies,[13,37,54,56] early posterior fossa surgery, more or less associated with PVD, must be the first step in the management of hydrocephalus in PFT. Indeed, postoperative hydrocephalus is only present in 18 to 40% of cases.[23,25,44] However, for theses studies,[23,44] the presence of metastases at presentation is the most important risk factor of postoperative hydrocephalus. Ependymomas and medulloblastomas also have a higher risk of postoperative hydrocephalus[23,44] related to their propensity to grow in a midline location near the fourth ventricle.[37] Thus, in our study, we observed the higher rate (57%) of shunt failure in the PVD group. Furthermore, children in the PVD group also had a higher rate of complications (43%) and infections (29%). Indeed, in the literature, external devices for the management of hydrocephalus in PFT are known to be a source of infective complications[37] even if antibiotic impregnated catheters reduce that risk.[56] For these reasons, we think that PVD before or during surgical removal of the primitive tumor should not be the first option in the management of hydrocephalus in childhood metastatic PFT at presentation.

VPS in childhood metastatic PFT

Historically, VPS is the most common shunt procedure used in childhood PFT before the emergence of ETV.[1] Indeed, recent studies have shown that ETV is superior to VPS in terms of safety, simplicity and resultant outcomes.[11,19] VPS includes risks of infection in the pediatric population with up to 20% infection-related mortality.[59] In our study, we observed only one case (25%) of infection in children who underwent VPS in first intention. However, this infection rate was not different between the three groups ($p = 0.17$). As described by Stovell and al.,[53] VPS is associated with a higher rate of infection than ETV but has lower immediate complications and failure rates. Thus, in our study, shunt failure was noted in only one case (25%) of children in the VPS group. However, the limited number of children included in the VPS group did not allow us to prove the superiority of this shunt procedure in these metastatic cases. Nevertheless, VPS was performed in 73% of cases after shunt failure and is for us a strong alternative after ETV failure. Among the 14 children who had VPS

in our study, only two cases (14%) of dysfunction were recorded. There were early dysfunctions and no events were reported thereafter. Notably, no cases of dissemination of tumor cells via shunt catheter to the peritoneal cavity were observed in contrast with many reports[2,3,5,9,22,29,30,38,39,48] and a 19% rate of extracranial metastasis after shunting in the literature.[29] Furthermore, although not significant, children were treated earlier in the VPS group.

Limitations and perspectives

In our study, except young age, we did not find any statistically clinical characteristics that would lead to identifying patients with increased risk of ETV failure at presentation. Indeed, CSF metastatic cells can be found only postoperatively after a shunt procedure. Similarly, we have not been able to highlight significant correlation between metastases identified by neuroimaging investigation and the risk of ETV failure or with the presence of CSF metastatic cells. Nevertheless, we observed a trend for the children who had ETV failure to present at least two metastatic sites. Thus, as suggested by a few authors,[6,13,45,56] and according to our experience, we think that ETV should be avoided when metastatic spread is objectified by the neuroimaging investigations. Otherwise, when an ETV has been performed, the presence of postoperative CSF metastatic cells should necessitate careful clinical monitoring. Because of impaired CSF absorption in metastatic PFT in children, we think that VPS could be used in these particular cases as a first step or after ETV failure. However, our retrospective study, undertaken with a limited number of patients, has not shown any significant difference between shunt procedures. Further investigations are required to confirm our hypotheses.

CONCLUSIONS

The management of hydrocephalus in childhood metastatic PFT at presentation poses challenges with a high risk (52%) of shunt failure. Furthermore, shunt failure indicates a poor prognosis with a significant decrease in cumulative survival in these cases. No significant differences on the outcomes were observed between shunt procedures. However, we observed a failure rate of 56% in children who were operated first by ETV. These patients who underwent ETV failure were significantly younger and had postoperative CSF metastatic cells. Our results argue for a particular mechanism of hydrocephalus that is not only obstructive in these metastatic cases. CSF metastatic cells may cause impaired CSF absorption and can explain the high risk of ETV failure in these cases. Despite the theoretical risk of dissemination of metastatic cells through shunt catheter, in our opinion, VPS appears to be a good alternative to ETV in metastatic cases of PFT in children in first intention or after ETV failure. In our study, this procedure allowed us to start the oncologic treatment earlier and showed good long-term results.

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FIGURES

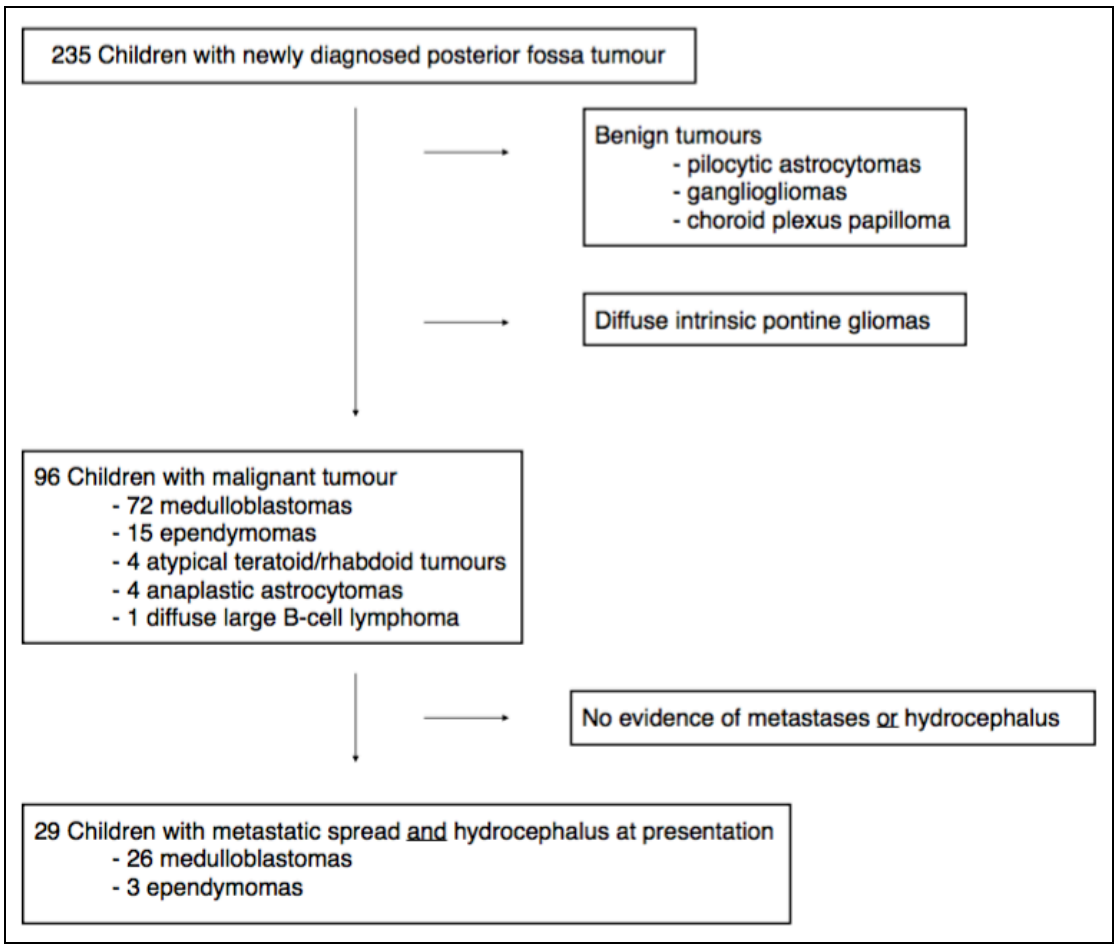
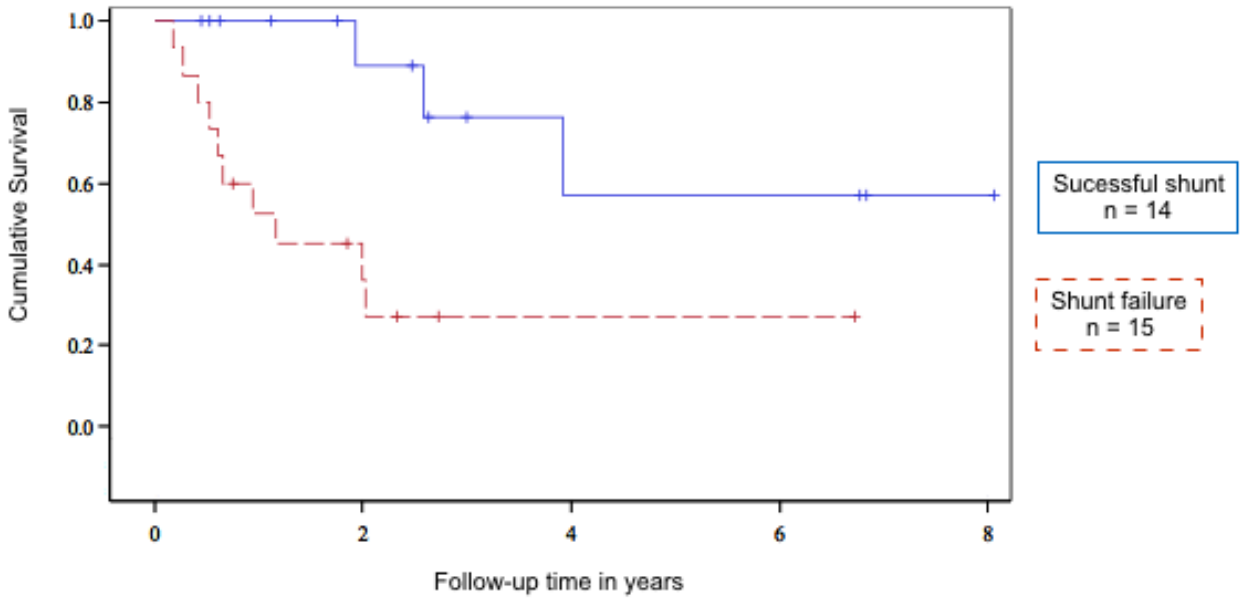


Figure 1. Flow chart of the 235 children who were admitted to AUH and RUH with newly diagnosed posterior fossa tumor from January 2005 to December 2015



Notches : censored data. Logrank test p = 0,0065

Figure 2. Kaplan-Meier survival curves plotted according to the occurrence of shunt failure in the study population

TABLES

Variables	No. of patients (%)*
Presentation	
male sex	19 (65.5)
mean age (years)	5.1 ± 2.7
intracranial hypertension	29 (100)
ataxia	24 (82.7)
bradycardia	11 (37.9)
lethargy	5 (17.2)
pappiledema	5 (17.2)
Duration of symptoms	
< 1 month	18 (62.0)
1-3 months	10 (34.5)
> 3 months	1 (3.5)
Hydrocephalus	29 (100)
transependymal edema	22 (75.8)

**unless specified otherwise. Mean values are presented as the means ± SDs.*

Table I. Clinical and radiographic data in 29 children with metastatic posterior fossa tumor at presentation

Variables	No. of patients (%)*
Primitive tumor mean size (mm)	44 ± 11.6
Primitive tumor location	
fourth ventricle	29 (100)
ponto-cerebellar angle	6 (20.6)
Metastatic spread	
supratentorial metastases	14 (48.3)
infratentorial metastases	16 (55.2)
spinal metastases	16 (55.2)
diffuse leptomeningeal spread	13 (44.8)

**unless specified otherwise. Mean values are presented as the means ± SDs.*

Table II. Primitive tumor and metastatic spread characteristics in the study population

Variables	No. of patients (%)*				p Value
	Total (n = 29)	VPS (n = 4)	ETV (n = 18)	PVD (n = 7)	
Incidence of shunt failure	15 (51,7)	1 (25,0)	10 (55,5)	4 (57,1)	0.66
Mean length of hospital stay (days)	24.1 ± 17.2	24.8 ± 22.2	24.6 ± 17.7	22.6 ± 15.4	0,83
Mean time to initiation of oncologic treatment (days)	23.7 ± 16.7	11 ± 10.2	26.9 ± 19.6	23.1 ± 6	0,12
Complication	9 (31,0)	1 (25,0)	5 (27,8)	3 (42,9)	0,84
infection	4 (13,8)	1 (25,0)	1 (5,5)	2 (28,6)	
haemorrahgei	1 (3,5)		1 (5,5)		
CSF leakage	6 (20,7)		3 (16,7)	3 (42,8)	
hyponatremia	2 (6,9)		2 (11,1)		
Second shunt procedure performed †					
ventriculo-peritoneal shunt (VPS)	11 (73,3)	1 (100)	8 (80,0)	2 (50,0)	
endoscopic third ventriculostomy (ETV)	3 (20,0)	6 (60.0)	1 (10,0)	2 (50,0)	
pre-resectional ventricular drainage (PVD)	1 (6,7)		1 (10,0)		

**unless specified otherwise. Mean values are presented as the means ± SDs.*

†Information and percentages refer to the 15 patients who had shunt failure and underwent a second shunt procedure.

Table III. Outcomes of the surgical management of hydrocephalus due to metastatic posterior fossa tumor in the study population

Variables	No. of patients (%)*				
	ETV success (n = 8)	ETV failure (n = 10)	Univariate p Value	Multivariate OR (95% CI)	Multivariate p Value
Clinical					
mean age (years)	6.3 ± 2.7	3.4 ± 2.1	0.041	1.77 [1.00-3.15]	0.05
postoperative CSF metastatic cells	1 (12.5)	7 (70.0)	0.025	16.33 [1.35-197.77]	0.028
Radiographic					
supratentorial metastases	3 (37.5)	6 (60,0)	0.63	NA	
infratentorial metastases	4 (50)	6 (60.0)	1	NA	
spinal metastases	4 (50)	5 (50.0)	1	NA	
leptomeningeal spread	3 (37.5)	6 (60.0)	0.63	NA	
at least 2 metastatic sites†	4 (57.1)	9 (100)	0.06	NA	
Management					
direct primitive tumor removal	6 (75.0)	6 (60.0)	0.64	NA	
mean time to initiation of oncologic treatment (days)	23.4 ± 11.8	30 ± 24.9	0,92	NA	

NA = not assessed

**unless specified otherwise. Mean values are presented as the means ± SDs.*

†Information and percentages are based on 7 and 9 patients only in the ETV success and ETV failure groups respectively.

Table IV. Factors associated with ETV failure in the second group

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Abstract	Object. Surgical management of hydrocephalus in metastatic tumors of the posterior fossa in children must be effective. Indeed, any reoperation related to hydrocephalus may be ... View full abstract
Keywords	hydrocephalus, childhood posterior fossa tumors, metastases, endoscopic third ventriculostomy, ventriculoperitoneal shunt
Specialties	Pediatric
Clinical Trial	No
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Surgical management of hydrocephalus caused by metastatic tumors of the posterior fossa in children

ABSTRACT

Object. Surgical management of hydrocephalus in metastatic tumors of the posterior fossa in children must be effective. Indeed, any reoperation related to hydrocephalus may be a life-threatening situation notably if neoadjuvant chemotherapy is mandatory before surgical removal. This study tried to retrospectively examine the effectiveness of the different shunt procedures used in these children and aimed to identify factors associated with shunt failure.

Methods. From January 2005 to December 2015, 29 children came to our institutions for hydrocephalus related to a metastatic posterior fossa tumor. All the children had signs of raised intracranial pressure caused by hydrocephalus and underwent a shunt procedure. Shunt failure was defined as the necessity to perform any subsequent shunt procedure within the 6 months following admission. Surgical complications related to hydrocephalus, length of stay in hospital, initiation of oncologic treatment, and survival including follow-up to December 2015, or time of death, were recorded.

Results. Four patients (14%) were operated by ventriculo-peritoneal shunt (VPS), 18 patients (62%) underwent endoscopic third ventriculostomy (ETV) and 7 (24%) patients had a pre-resectional ventricular drainage (PVD) before or during surgical removal of the primitive tumor. No difference was observed on the outcomes between the three groups. However, high rates of shunt failure (52%) and of surgical complications (31%) were reported. The mean follow-up time in the study population was 27,2 months (range 3 - 90). A significant decreased in cumulative survival (p = 0,0065) was observed in children who had a shunt failure. 56% of patients operated with ETV had shunt failure. These patients were significantly younger (3,4 versus 6,3 p = 0,041). The presence of cerebro-spinal fluid (CSF) metastatic cells was significantly associated with ETV failure (OR 16,33 [95% CI 1,35-197,77], p = 0,028). Patients operated first by VPS first started their oncologic treatment earlier and after shunt failure a VPS was done in 73% of cases. Long-term follow up of children who underwent a VPS showed only two cases of early dysfunction. No case of dissemination and extracranial metastasis through the catheter was reported.

Conclusions. CSF metastatic cells may cause impaired CSF absorption that could lead to hydrocephalus. Thus, in metastatic posterior fossa tumors, the mechanism of hydrocephalus may not only be obstructive. This hypothesis may explain the lower efficiency of ETV and PVD for the management of hydrocephalus in metastatic posterior fossa tumors in children. VPS allows us to start the oncologic treatment earlier and could be a good option in first intention or after ETV failure in these metastatic cases.

Keywords : hydrocephalus, childhood posterior fossa tumors, metastases, endoscopic third ventriculostomy, ventriculoperitoneal shunt

LE FOURNIER Luc

Prise en charge de l'hydrocéphalie dans les tumeurs métastatiques de la fosse cérébrale postérieure chez l'enfant

RÉSUMÉ

La prise en charge chirurgicale de l'hydrocéphalie dans les formes métastatiques des tumeurs de la fosse cérébrale postérieure de l'enfant se doit d'être efficace. L'objectif de cette étude était de déterminer de manière rétrospective l'efficacité des différentes procédures chirurgicales de dérivation utilisées dans le traitement de l'hydrocéphalie chez ces enfants et d'analyser les facteurs de risque en cas d'échec.

De Janvier 2005 à Décembre 2015, 29 enfants ont été admis dans nos centres pour une hydrocéphalie liée à une tumeur métastatique de la fosse cérébrale postérieure. Tous les enfants ont eu un geste de dérivation devant des signes d'hypertension intracranienne causés par l'hydrocépahlie. L'echec de cette procédure a été défini comme la nécessité de réaliser une autre dérivation dans les six mois suivant l'admission. Les complications chirurgicales liées à ces procédures, la durée d'hospitalisation, l'initiation du traitement oncologique et la survie incluant le suivi à long terme juqu'en Décembre 2015 où à la date du décès ont été recueillis.

4 patients (14%) ont été opérés par une dérivation ventriculo-péritonéale (DVP), 18 patients (62%) ont eu une ventriculocysternostomie (VCS) et 7 patients (24%) ont eu un drainage ventriculaire temporaire (DVT) avant ou pendant l'éxérèse de la tumeur primitive. Aucune différence n'a été constatée entre les différentes procédures concernant les suites post-opératoires. Néanmoins, il a été observé un taux élevé d'échec (52%) et de complications (31%). Une diminution significative de la survie a été mise en évidence chez les enfants ayant eu une réintervention (p=0,0065). 56% des enfants ayant eu une VCS ont été réopérés. Ces enfants étaient significativement plus jeunes (3,4 versus 6,3 p = 0,041) et avaient des cellules métastatiques dans le liquide cérébro spinal (LCS) [95% CI 1,35-197,77], p=0,028). Dans 73% des cas d'échec de dérivation initiale, une DVP a été réalisée. Aucun cas de dissémination métastatique extra-cérébrale n'a été rapporté.

Les cellules métastatiques circulantes dans le LCS peuvent causer des troubles de résorption du LCS et ainsi contribuer à l'hydrocéphalie observée dans les tumeurs métatstatiques de la fosse cérébrale postérieure de l'enfant dont le mécanisme ne semble pas uniquement obstructif. Cette hypothèse peut expliquer l'efficacité moindre de la VCS et du DVT dans la prise en charge de ces cas justifiant l'utilisation de La DVP en première intention ou en cas d'échec de VCS.

Mots-clés : hydrocéphalie, tumeurs de la fosse postérieure de l'enfant, metastases, ventriculocisterstomie, dérivation ventriculo-péritonéale

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