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Clinical case

Subdural hematoma after endoscopic third ventriculostomy: Struggling against the Laplace law

Hématome subdural après ventriculocisternostomie endoscopique : luttant contre la loi de Laplace

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ABSTRACT

Background. – Endoscopic third ventriculostomy (ETV) is an ideal treatment for obstructive hydrocephalus. Although ETV is a safe procedure, several complications related to this procedure have been reported in the literature. We present a rare case of late onset symptomatic bilateral subdural hematoma after an uneventful ETV that proved particularly difficult to solve.
Case description. – A 61-year-old male patient presented in our neurosurgery department three months after ETV (aqueductal stenosis) with progressive headaches and anomic aphasia. The MRI revealed bilateral chronic subdural hematomas (chSDH). They were treated via a burr hole evacuation, subduroperitoneal and external subdural drains proving to be refractory to the first two strategies. Postoperatively, his headaches improved. At the last follow-up the patient's status remains improved and there is no radiological evidence of significant residual collections.
Conclusion. – This case confirms that chSDH formation is a rare possible complication following ETV even in the presence of a normal early postoperative image. Patients should be followed-up more closely for possible subdural collection formation. In the cases of very long-term hydrocephalus with a thin cerebral mantle, brain elastic properties are likely to be altered. As there is no possibility to close the internal shunt, the stoma, we advocate external subdural drainage to reinflate the brain, in the first intention or at least after an initial failed burr hole evacuation.

Mots clés :
Loi de Laplace
Hématome sous-dural
Ventriculocisternostomie endoscopique

RÉSUMÉ

Introduction. – La ventriculocisternostomie endoscopique est un traitement idéal pour l'hydrocéphalie obstructive. Bien qu'étant une procédure sûre, quelques complications ont été décrites dans la littérature. Nous présentons ici un rare cas d'hématomes sous-duraux chroniques bilatéraux, tardifs et symptomatiques, après une ventriculocisternostomie endoscopique efficace, et de résolution particulièrement difficile.
Description du cas. – Un homme de 61 ans s'est présenté trois mois après une ventriculocisternostomie (sténose de l'aqueduc) avec des céphalées progressives et une aphasie anomique. Les images d'IRM ont mis en évidence des hématomes sous-duraux chroniques bilatéraux. Ceux-ci ont été traités par double trépanation bilatérale, drain sous-dural péritonéal puis drains sous-duraux externes, car réfractaires aux deux premières stratégies. En postopératoire, les céphalées ont presque disparu. Au moment du dernier contrôle, le patient reste amélioré et sans évidence radiologique de récidive des collections.

Abbreviations: ETV, endoscopic third ventriculostomy; CSF, cerebrospinal fluid; SDH, subdural hematoma; MRI, magnetic resonance images; chSDH, chronic subdural hematoma; CT, computed tomography; NaCl, sodium chloride solution.

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Conclusion. – Ce cas confirme que la formation d'hématomes sous-duraux chroniques est une complication rare mais possible dans les suites d'une ventriculocisternostomie endoscopique, même en présence d'une image postopératoire précoce normale. Les patients doivent être suivis d'une manière rapprochée pour cela. En cas d'hydrocéphalie chronique avec une épaisseur cérébrale diminuée, les propriétés élastiques peuvent être altérées. En raison de l'impossibilité de fermer la communication, la stomie, nous préconisons un drainage sous-dural externe pour réexpandre le cerveau, en première intention ou au moins après un premier échec de drainage par trépanation.

1. Introduction

Endoscopic third ventriculostomy (ETV) has become an established method for the treatment of obstructive hydrocephalus, replacing shunt procedures in many cases, particularly in aqueductal stenosis [1]. Shunt-related complications (infection and over drainage, among others) are therefore avoided.

The calculated complication rates of ETV technique were found to be smaller than those of shunts [1–4], which made it a more reliable and appropriate procedure for selected cases. Among other factors, this can be explained by the fact that it is performed under direct visualization [4,5]. Complications after ETV have been reported with a rather low incidence, most of them related to an injury to the anatomic structures surrounding the ventricular system. One can enumerate the various infections (meningitis, ventriculitis), cerebrospinal fluid (CSF) leakage, intraoperative subarachnoid hemorrhage, basilar artery injury including aneurysm formation, cardiac events (arrhythmia with cardiac arrest), epilepsy, endocrine disturbances due to hypothalamic dysfunction, confusion, memory loss, hemiparesis, herniation syndrome, oculomotor palsy, Horner's syndrome, epidural hematoma, subdural hematoma and/or hygroma (SDH) [1,3,4]. Overall, increasing experience with this technique has shown to reduce morbidity and mortality as well, but still more detailed reports on specific complications are needed.

In particular, only nine cases have been reported regarding subdural collections after ETV [2,5,7–13], which is a well-known complication of VP shunts, pathophysiologically explained by an over drainage phenomenon. Most of them were discovered three to four weeks after the first procedure and two thirds were asymptomatic. Seven ended in burr hole drainage with only the need of one procedure. There was no subduroperitoneal derivation.

We report the case of a large, bilateral and refractory subdural hematoma, focusing the discussion on the management and possible mechanisms of SDH after ETV.

2. Case description

A 61-year-old male patient underwent an endoscopic third ventriculostomy for the treatment of a long-term obstructive hydrocephalus (aqueductal stenosis) that markedly improved symptoms (Fig. 1). A ventricular catheter connected to a subgaleal Ommaya reservoir was left in place in the event of a malabsorptive component from a hydrocephalus that could develop in the future. The patient presented three months after surgery, complaining of progressive headaches, progressive and anomic aphasia. He had no memory problems, urinary incontinence or any worsening gait disorders. Clinical examination confirmed a mild aphasia with no other focal neurological disorder. There was no history of trauma or coagulation disorders.

Magnetic resonance imaging (MRI) showed bilateral chronic subdural hematomas (chSDH) with a mass effect (maximal thickness of 4 cm on the left and 2 cm on the right side). These collections were drained via four burr hole trepanations with two subgaleal drains left in place for two days (Fig. 2).

A postoperative CT scan (day 1) showed a marked decrease of the collection volume in agreement with the good clinical evolution. Another CT scan prior to discharge (day 5) demonstrated a slight increase of the chSDH. As the patient remained asymptomatic, a conservative approach was chosen, and a follow-up CT scan performed (day 14), confirming a further increase in the volume of the chSDH, also with a component of new acute bleeding. Taking into account this unequivocal evolving process, the patient had a bilateral subduroperitoneal shunt inserted, connected in Y, three weeks after the first evacuation procedure.

The patient was then discharged six days after the second procedure in a good condition after two consecutive postoperative CT scans demonstrating a moderate regression of the chSDH as compared to the preoperative scan.

Follow-up CT scans, one week after discharge, revealed a right-sided persistent collection, with 2.2 cm of max diameter with no clinical change. A further CT scan was repeated three weeks later showing a duplication of both collections associated with new headaches and gait instability. Based on these new results, further surgery was performed. During this procedure, both internal subdural drains were found to be occluded, which is why they were externalized after hematoma evacuation. These drains where placed −30 cm below the Monro's foramina and were ablated on Day 1 after a favorable CT scan follow-up which showed that the brain convexity had almost reached the calvaria. Also clinically the patient became asymptomatic, and was therefore subsequently discharged.

The MRI performed 5 months after the last procedure, confirmed an almost complete reabsorption of both collections and re-expansion of the brain, with only a slight right frontal superior chSDH of a few millimeters (Fig. 3).

3. Discussion

Endoscopic third ventriculostomy is generally accepted as the procedure of choice for the treatment of hydrocephalus on aqueductal stenosis. This procedure is considered to be simple, fast and safe, avoiding over drainage, infection and shunt malfunction, as well as inherent shunt-related complications. Data from several series of patients who had undergone ETV have been published [1–4]. Only four papers have focused on the general complications in neuroendoscopic procedures. Most data regarding severe ETV complications have been published as case reports, with overall complication and mortality rates ranging from 0 to 20% and 0 to 1% respectively.

Subdural collections or hematomas are frequently observed after shunt placement, but rarely after ETV [1]. SDH result from the over drainage-related phenomenon after ventricular shunt introduction even with an antisiphon device. Increase in the differential pressure applied to the shunt resulting from the hydrostatic pressure difference between the head and the abdomen may lead to

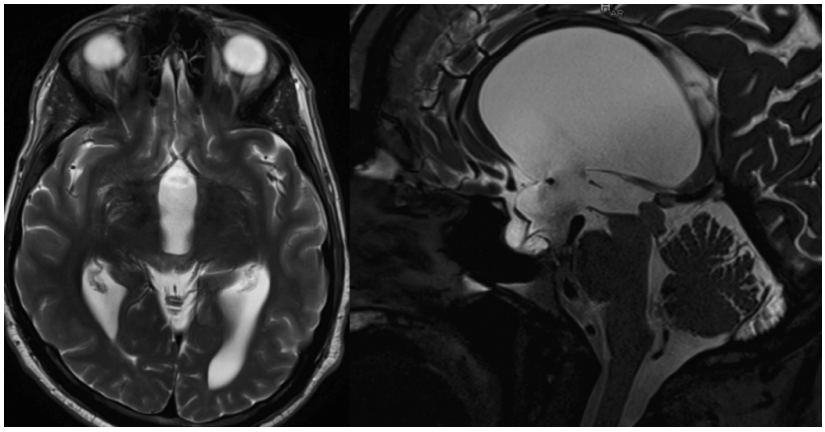

Fig. 1. MRI sequences axial/sagittal before ETV showing aqueductal stenosis and subsequent hydrocephalus.
Séquences IRM axiale/sagittale avant ventriculocisternostomie, démontrant la sténose aqueductale et l'hydrocéphalie consécutive.

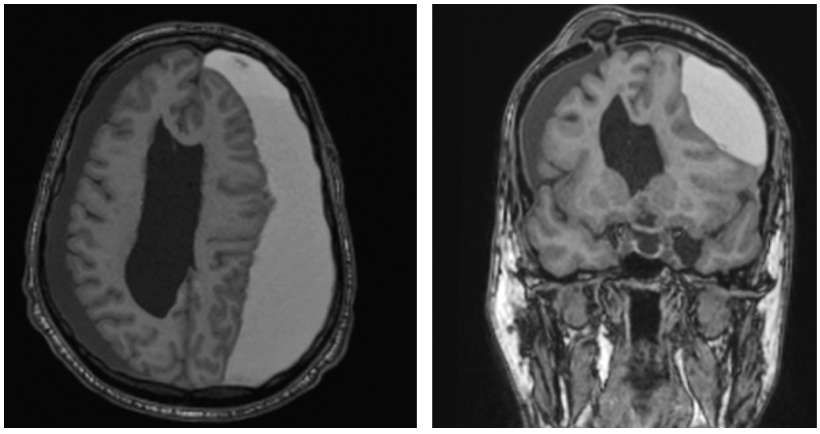

Fig. 2. MRI sequences axial/coronal 3 months after ETV with bilateral chronic subdural hematomas (chSDH) with mass effect.
Séquences IRM axiale/coronale 3 mois après ventriculocisternostomie avec des hématomes sous-duraux chroniques bilatéraux et effet de masse.

over drainage. The overall incidence of over drainage in long-term shunt patients ranges from 10 to 12% and represents less than 10% of shunt failures in one reported pediatric series and approximately 30% in the adult series [1–6].

Only nine subdural collections post-ETV [2,5,7–13] were found after an extensive PubMed search. Most of them occurred in patients suffering from hydrocephalus in which there was a thin cerebral mantle.

Several hypotheses have been postulated regarding the pathophysiology of SDH after the ETV procedure. They may be divided in two groups, the first one considering acute postoperative changes and the second based on more slow and late structural changes [7].

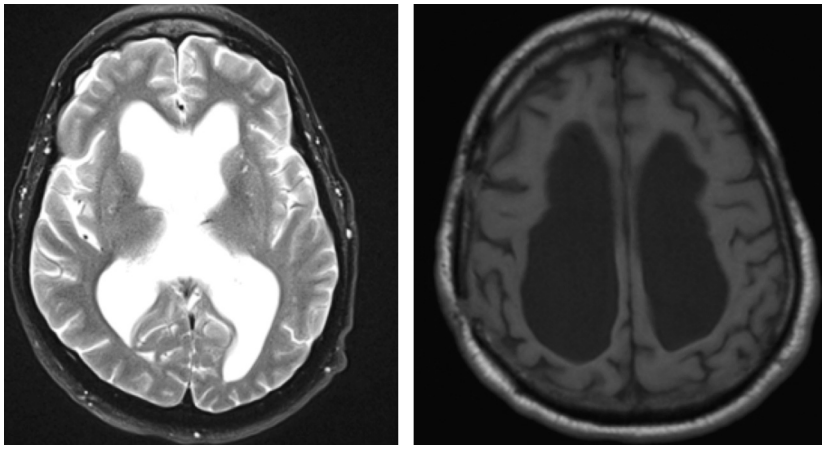

Fig. 3. MRI axial sequences 5 months after drainage without chSDH.
Séquences IRM axiales 5 mois après drainage sans hématomes sous-duraux.

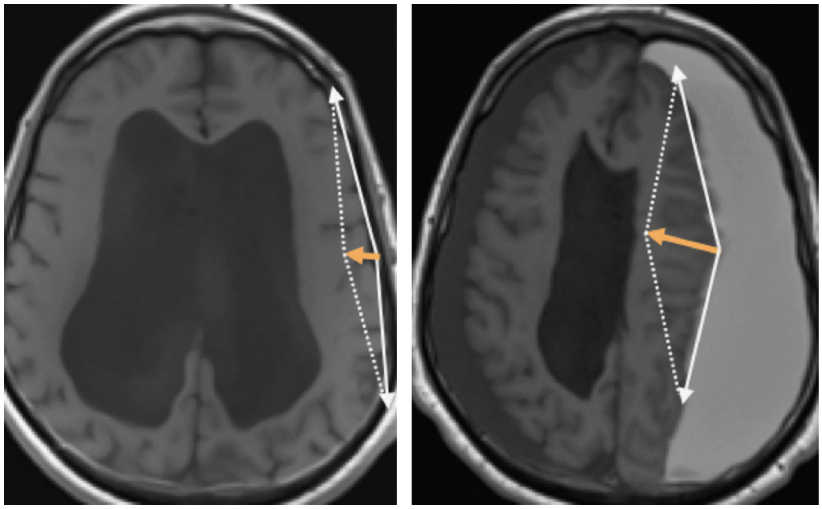

Fig. 4. Schematic representation of the vectors on the brain surface. The distance between the cerebral mantle and the skull/curve radius and pressure differential resultant vector are directly proportional. The resultant vector is almost negative when in the absence of SDH, offering almost no resistance to the brain surface, as a filled balloon with more resistance at the beginning and a decreasing force to keep it inflated with an increased diameter.
Schéma des vecteurs à la surface cérébrale. La distance entre le cerveau et le crâne/rayon de la courbe et le vecteur résultant de la pression différentielle sont directement proportionnels. Le vecteur résultant est presque nul en l'absence d'HSD, n'offrant presque pas de résistance à la surface cérébrale, comme pour un ballon plein avec plus de résistance au début et une force décroissante pour le maintenir gonflé avec un diamètre augmenté.

On one hand, the etiology of a subdural hemorrhage post-ETV may include technical aspects such as damage to a cortical vessel or bridging vein at the time of the ETV or bleeding from a scalp vessel that accumulated in the subdural virtual space [1,14]. Also some authors have postulated that sudden and abundant ventricular CSF drainage during the ventriculostomy procedure might enlarge the subdural space, tearing a bridging vein, thereby allowing the collection of subdural blood [8]. There is also the possibly of postoperative ventricular CSF outflow through a malocclusion corticotomy into the subdural space with the formation of a subdural hygroma in which blood could secondly accumulate by torn bridging veins [15]. However, in our patient's case the subdural hemorrhage did not occur immediately postoperatively as the postoperative MRI (day 4) showed no subdural collection and the patient experienced a clinical improvement following ETV that lasted for several weeks.

On the other hand, more insidious biophysical changes may explain a subdural collection after ETV [1,3,16,17]. Patients with a disproportion between the skull and the brain due to a massive ventricular dilatation during years or decades present with a thin cerebral mantle, which can lead to a SDH. These patients often have diminished cerebral elasticity in order for the brain to return against the skull, and with a greater difficulty in filling the subdural space following ETV, consecutively tearing a bridging vein. The stoma should permit a physiological drainage of the ventricles into the subarachnoid spaces without siphoning but a small decrease of ventricular pressure nonetheless may occur after bypassing the aqueductal obstruction. In the majority of patients, this minute decrease in intraventricular pressure still allows the ventricular walls to remain in balance with a cerebral mantle, which is still stiff enough, and the ventricular volume remains augmented. To summarize the main points, the Laplace law or Laplace-Young equation relates the local interface curvature separating two adjacent chambers with the pressure difference between both environments. When the interface is curved, the magnitude of the resultant vector of the wall tensions determines that the pressure difference required to maintain the inflated sphere is inversely proportional to the sphere curvature radius (Fig. 4). Almost 50 years ago, this law was referred to in neurosurgery to explain why the ventricles remain inflated (i.e. a large radius) in a normal pressure hydrocephalus despite normal pressure applied on the ventricular walls [18].

Moreover, some authors assume that acute intracranial pressure changes after ETV created by a new CSF pathway, which can cause sudden changes in the CSF regulation system. Although ETV results in a decrease of the lateral and third ventricular volumes as CSF flows from the ventricles into the subarachnoid cisterns, the CSF absorption rate does not increase as rapidly and this results in an increase in the CSF subarachnoid space volume [7,8,14]. This may injure the arachnoid membranes inducing a traumatic rupture of the arachnoid villi and granulations with subsequent valvular dysfunction. This could then result in a subdural hygroma. Once a subdural hygroma develops, if the CSF regulation system does not adapt to the change in the CSF pathway [8,14], the hygroma will increase in volume and could subsequently evolve into a SDH by venous bleeding. CSF collections persisting in the subdural space for more than a few weeks are thought to induce the migration and proliferation of inflammatory cells derived from dural border cells, resulting in a layer of fibroblasts along the dura that develops into the outer membrane of the hematoma [2]. Thus, the delayed absorption of a subdural effusion is likely to result in hemorrhage into the subdural fluid due to either tearing of bridging veins or bleeding from the neomembrane [2].

A combination of both processes could explain our case. A disequilibrium between ventricular pressure and ventricle radius, a thin cerebral mantle and a loss of parenchymal elasticity all seem to be factors predisposing to this refractory complication after having apparently physiologically reestablished the internal major CSF pathways by the ETV.

4. Conclusion

ETV in hydrocephalus on aqueductal stenosis is a safe, reliable and an effective surgical choice with low rates of morbidity and mortality. However, rare complications such as subdural hematoma or hygroma should be kept in mind even if the "intracranial shunt" provided by the ETV eliminates siphoning. In our case the massive and refractory SDH was definitely a major factor of morbidity and could have been fatal.

In the cases of very long standing hydrocephalus with small cortical mantles, brain elastic properties are likely to be altered. In the presence of a large subdural collection, i.e. a case of hydrocephalus

where the “internal shunt” cannot be closed, we recommend the use of a transitory external subdural drain placed below the head (mild depression) to allow the cerebral mantle to increase the curvature radius in order overcome the Laplace law and remain inflated by the lowered ventricular pressure. Although controversial in terms of risk of recurrence and complications rate in chSDH [19–21], a prolonged period of bed rest (4-7 days) with progressive head elevation could also be considered and attempted in this type of a specific SDH case. In some cases, this may potentially prevent the necessity of a second procedure comprising the insertion of a subdural drain.

Despite the restoration of a physiological CSF drainage without siphoning after ETV, some measures should be taken to minimize the risk of collapse of a thin cerebral mantle. The size of the endoscope should be considered to be as small as possible and pressure-controlled catheters can be used during surgery to prevent excessive CSF drainage, perhaps replacing lost CSF with isotonic NaCl or lactated Ringer’s solutions [14]. Also the importance in the closure of the cortical opening to prevent CSF leakage into the subdural space has to be considered.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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