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Use of TachoSil® as a dural sealant in decompressive craniectomies

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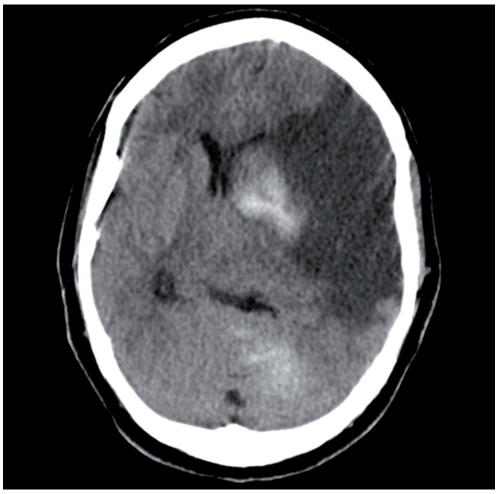

Image 1

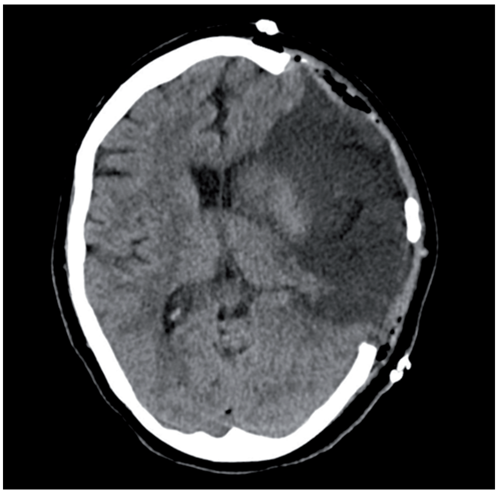

Image 2

Introduction

Decompressive craniectomy remains a component of the therapeutic approach for cases of refractory intracranial hypertension to medical treatment in cases of subarachnoid hemorrhage or infarction, among others. It is habitual over the course of several weeks or months between the initial procedure and replacement of the bone defect (autologous or heterologous).

Technically it is presumed to be an accessible procedure for any neurosurgeon, however, the percentage of potential complications is not negligible, and its incidence varies between 13.4 % up to 50 %[1]: bleeding, seizure crisis, hydrocephalus, infections of the surgical wound or cerebrospinal fluid (CSF) fistulas, among others. The incidence of the latter has been reported in up to 8.8 % of the cases[2].

The use of TachoSil® as a dural sealant is recommended in the case of a decompressive craniectomy.

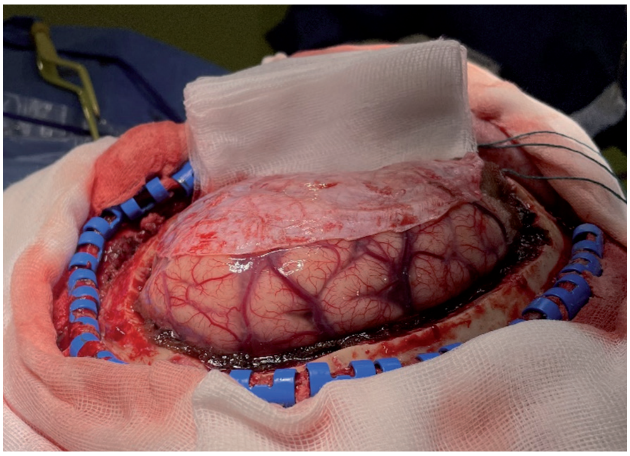

Image 3

Image 4

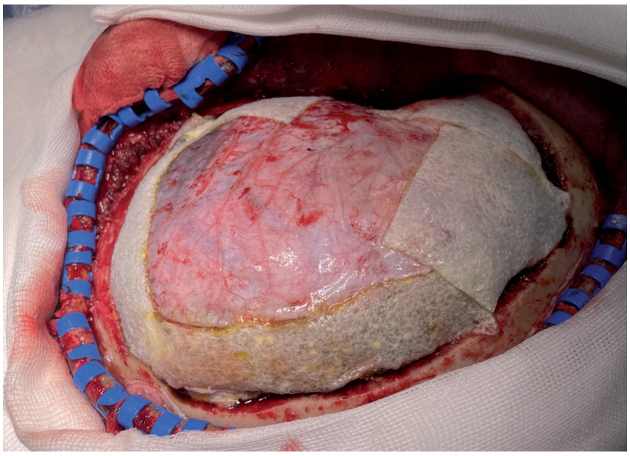

Image 5

Clinical case

A 47-year-old patient was admitted to the emergency department due to the abrupt onset of an hour of duration of symptoms consisting of alteration of speech and comprehension and weakness of the right side of the body. A baseline computerized tomography (CT) scan and cerebral perfusion sequence were performed, showing an image suggestive of ischemia in the right middle cerebral artery (MCA) territory. In angio CT, a full repletion defect in segment A1 of the anterior cerebral artery and segment M1 of the MCA are observed. Endovascular thrombectomy is indicated. During the procedure contrast extravasation is produced, finally achieving a partial recanalization *(→ Image 1)*. After a 48-hour period, the patient's condition demonstrated a decline in the neurological examination with decerebrate posture of the right hemisphere. A new cranial CT scan was performed showing signs of malignant MCA infarction with a midline deviation of 10 mm and uncal and subfalcine herniation *(→ Image 2)*. An urgent decompressive craniectomy was indicated.

The surgical procedure was performed without incidents. After confirming the adequate hemostasis, surgical closure was performed *(→ Image 3)*.

The space between the dural borders was covered with Surgicel® (subdural) and TachoSil® was applied (two patches of 9.5 x 4.8 cm), cropped as required, and placed them over both dural borders *(→ Images 3, 4, and 5)*.

A 10 mm Jackson-Pratt type drain was placed in the epidural location. Closure of muscle-cutaneous flap by planes according to standard technique.

A cranial CT was performed 24 – 48 hours after the intervention. A plane of separation between the parenchyma and the muscle-cutaneous flap was identified, not observing accumulation of CSF *(→ Image 2)*.

During follow-up, CT was performed after two weeks *(→ Image 6)* which describes a hernia of the cerebral parenchyma and a small compatible subgaleal collection compatible with pseudomeningocele. The wound remained dry at all times, with a good appearance. The clinical evolution of the patient has been favorable, the patient remained conscious, although it does not connect with the surroundings and right hemiparesis persists, pending transfer to a medium-term care center.

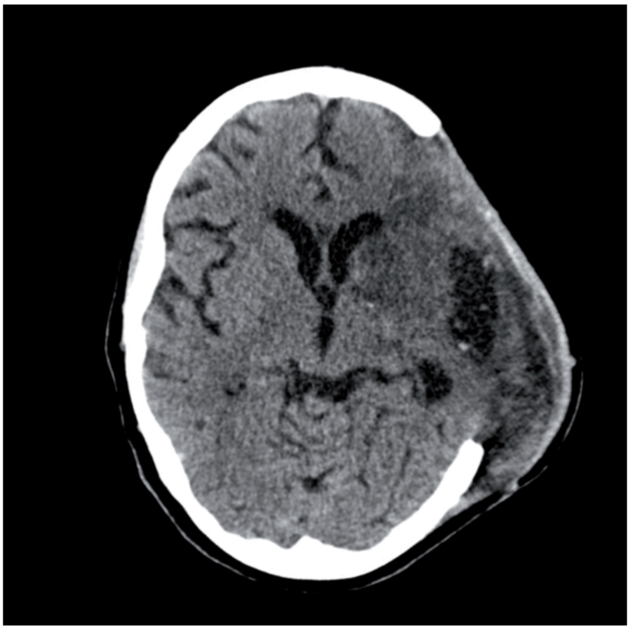

Image 6

Discussion

The dural opening is an essential step in the decompressive craniectomy procedure, which allows the expansion of the cerebral parenchyma (reducing the pressure by increasing the volume).

As a result, a section of the cerebral parenchyma surface was left without dural lining and, afterward, in contact with the muscle-cutaneous flap when closure took place. This generates adherence, increasing the difficulty of finding a dissection plane and provoking damage to the cerebral parenchyma when the patient was reintervened to repair the cranial defect (cranioplasty).

An ideal material to cover this dural defect would be one that is flexible/elastic, watertight and that maintains a dissection plane over the cerebral parenchyma. Various dural substitutes or materials exist that are specially designed and used to maintain this plane, some of them are the Gore-Tex patch, bovine pericardium or collagen[3].

The literature was reviewed to compare closure techniques in cases of decompressive craniectomies, and the article of Vieira et al.[4] is worth noting, which compares the incidence of complications between the two dural closure techniques (hermetic vs. non-hermetic) without finding statistically significant differences. A brief comment during the discussion was that no clinically relevant differences were found (although there was statistical significance) in the surgical time of the bone replacement, however since the study was not designed for this purpose, this conclusion may be altered due to diverse biases. Considering the statistical aspects of the study, it is worth pointing out that, a non-significant p-value with respect to the incidence of complications comparing the two different techniques, does not allow assurance that these techniques are "equal". In order to do so, a non-inferiority study[5] should be considered.

It can be complex to calculate the increase in the size of the dural plasty considering that the parenchyma may not necessarily reach its maximum degree of expansion at the time of the intraoperative closure. A slightly elastic material such as TachoSil® would permit a certain expansion of the brain after closure.

According to the TachoSil® technical data, the degrading period of the same is around twelve weeks (three months) although remains may be found for up to twelve months[6]. Although no consensus exists about the ideal moment for the bone replacement (early vs. late cranioplasty), some studies suggest two to three months as a margin for the replacement to prevent complications such as trephined syndrome[7]. There is no reason to suppose that the reabsorption time for TachoSil® represents an inconvenience for its use, and it may reduce the incidence of CSF fistulas, as it provides more time for the scalp to close.

A clinical case is presented on this new indication for a sanitary product currently being sold, TachoSil®, including its limitations for use. Follow-up studies should be carried out to evaluate the incidence of pseudomeningocele or CSF fistula, as well as the consequences of using this product at the time of the surgical replacement of the bone flap, and the presence of complications associated with the intervention.

In this case, the intention was to demonstrate the double advantage of TachoSil®, as a material to minimize the risk of postoperative pseudomeningocele and/or CSF fistula while creating a dissection plane that permits the safe replacement of the bone flap.

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2

Cerebral hypertension syndrome secondary to liquor fistula of anterior sacral meningocele after gynecological surgery. Clinical case, surgical repair, and sealing

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Introduction

The anterior sacral meningocele is an infrequent form of spinal dysraiphsm. It tends to appear in young people, with a slight predominance in the female sex. It may form part of complex malformation syndromes such as Currarino syndrome or diseases such as the Marfan syndrome and type I neurofibromatosis.

It may be diagnosed incidentally in asymptomatic patients or in the context of various urological, digestive or gynecological clinical conditions. Its management includes observation of asymptomatic patients and surgical treatment may be indicated in symptomatic patients, in cases where progressive growth is demonstrated with clinical repercussion of the cele and in young women with significant cysts and gestational desire, to prevent future obstetric problems.

Cerebrospinal fluid (CSF) fistulas associated with anterior meningocele are even more unusual and almost exceptional. This fistula may be accompanied by cerebral hypotension syndrome and the management of it depends, among others, on its particular anatomy and its etiopathogenesis.

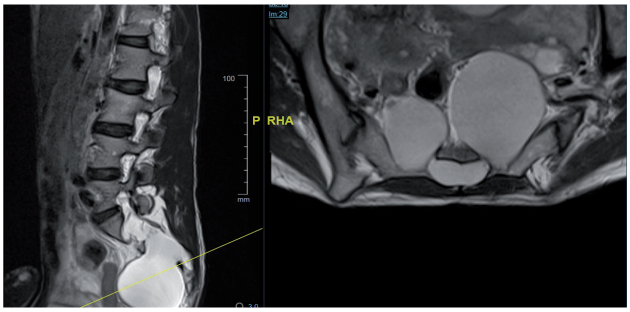


Image 1: MRI T2-enhanced lumbosacral spine (sagittal left-axial right). Anterior sacral meningocele that is informed as large Tarlov cysts protruding toward the pelvis.

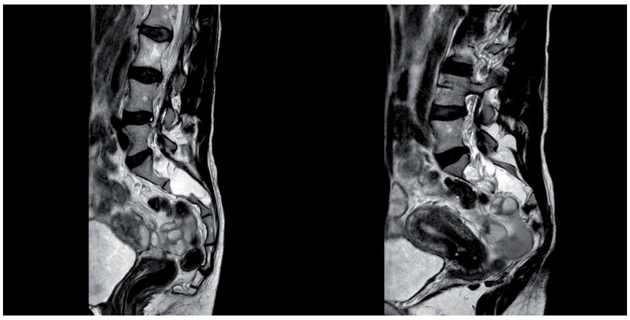


Image 2: MRI T2-enhanced lumbosacral spine; sagittal slices. Emptying of anterior sacral meningocele is observed. Probable defect of wall and fistula in meningocele.

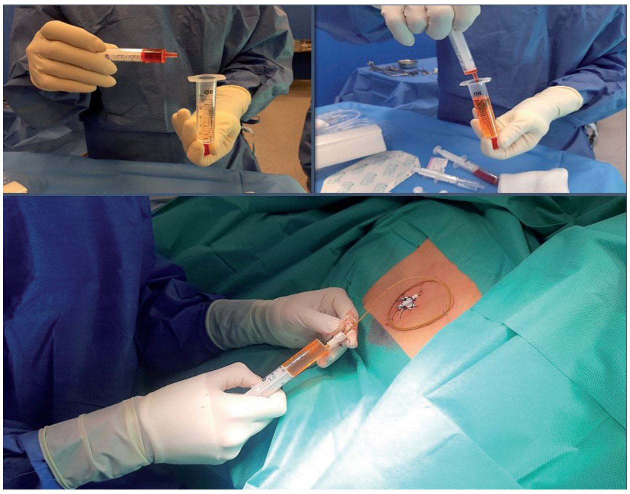


Image 3: Procedure of mixing 2 ml of fluorescein with 8 ml of CSF (above). Intrathecal injection of resulting mixture through external lumber drain (below).

Clinical case

Female of 41 years of age, with a history of collagenosis clinically compatible with Ehlers-Danlos syndrome, intervened a year ago by the gynecological service due to pararectal cysts – presacral through laparoscopy due to suspicion of adnexal pathology.

In the postoperative gynecological surgery, the patient presented with very intense nuchalgia and cervicalgia that increased when changing the position from decubitus to prone, irradiating to both upper limbs, associated with motor clumsiness and loss of strength in both hands, as well as allodynia in the same and repeated vomiting.

An MRI was performed in which dural level contrast uptake in the cervical conjunctival foramina was identified with a malformation of the atlanto-occipital articulation and deformity of the medullary junction. The patient was studied to rule out infectious diseases (including TB), tumors and inflammatory pathologies such as sarcoidosis. Another probable diagnosis was a cervical lesion due to the cervical and foramen magnum stenosis that appeared in the context of possible ligament instability due to collagenosis, which was aggravated by relaxation during general anesthesia.

A retrospective analysis of the complementary tests performed prior to the episode revealed an MRI of the lumbar column performed four years before, in which very large Tarlov cysts that protruded into the pelvis (→ *Image 1)* were identified.

Afterwards, a new neuroaxis MRI was performed in which alterations congruent with intracranial hypotension (bilateral laminar subdural collections, venous sinus ectasia, descent of the splenium from the corpus callosum and of the cerebellar tonsils up to 6 mm, as well as anterior dural thickening, and enhancement in C1 – C2) probably secondary to anterior sacral meningocele with a probable leak of CSF (compared to the prior MRI meningocele emptying was observed with possible defect on the left side) *(→ Image 2).*

With all of this, and since the clinical-radiological results were compatible with intracranial hypotension secondary to iatrogenic CSF fistula in the context of anterior sacral meningocele, treatment with a hemostatic patch was chosen as the first option.

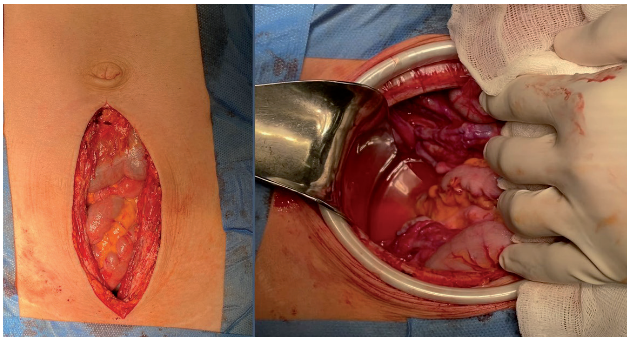


Image 4: Midline laparotomy approach (left). Identification of free peritoneal fluid not stained with fluorescein (right).

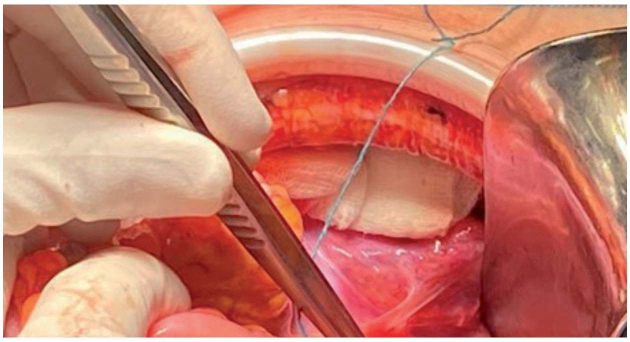
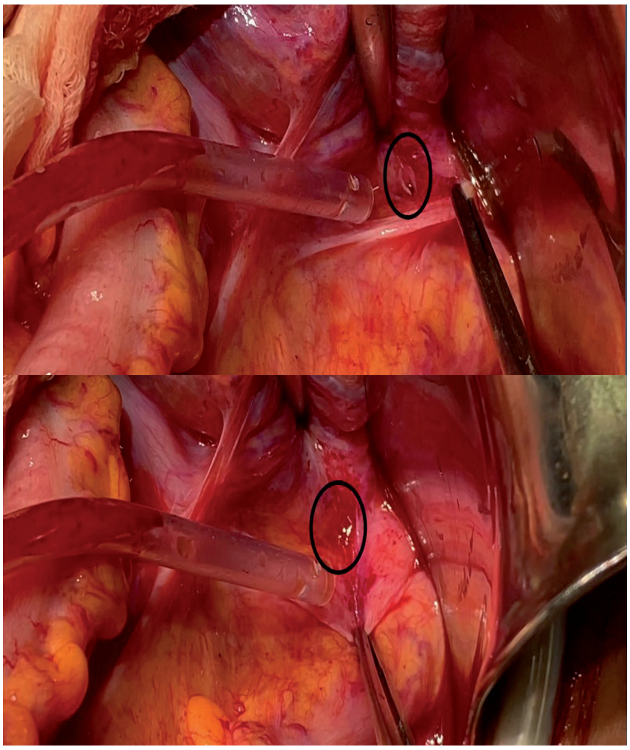


Image 5: Identification of CSF stained with fluorescein in peritoneal cavity.



Images 6 and 7: Defect in the left posterior parietal peritoneum and drainage of CSF stained with fluorescein (respectively).

However, the patient did not show a clinical improvement, and in fact a few days later presented a decline with intense headache, facial paresis and decreased strength in all four extremities.

The patient requested a second opinion from our center. After reviewing the existing literature and presenting the clinical case in a multidisciplinary session, surgical treatment was indicated using an exploratory anterior transperitoneal approach and closure of the CSF fistula, prior to intrathecal injection of fluorescein through an external lumbar drain. The surgery was performed using neurophysiological monitoring.

In the first stage, a lumbar puncture was performed to introduce the external lumbar drain. An extraction of 8 ml of CSF that was mixed with 2 ml of flourescein was made, and the resulting 10 ml were introduced at the intrathecal level *(→ Image 3).*

Then proceeding to a midline laparotomy, with a transperitoneal approach, identifying a large amount of free peritoneal liquid (compatible with probable accumulated CSF prior to the fluorescein injection); *(→ Image 4).* The opening of the posterior parietal peritoneum was performed by exposing the anterior sacral wall at level S1 – S2. A detective bone with a meningocele was identified at this level, but a fistula was not found in this location, confirming the integrity of the dura mater. In free scanning electromyography small insignificant discharges of the external sphincter appeared during the manipulation of the S2 foramina. The patient had an inferior transverse scar due to a prior caesarean section but did not pose problems for the approach and no significant adherences or flanges were found that interfered with the surgery.

After a few minutes of exploratory surgery a new accumulation of CSF stained with fluorescein was observed in the peritoneal cavity, identifying a fistulous trajectory with an opening in the peritoneal cavity through the left posterior parietal peritoneum *(→ Images 5, 6 and 7).*

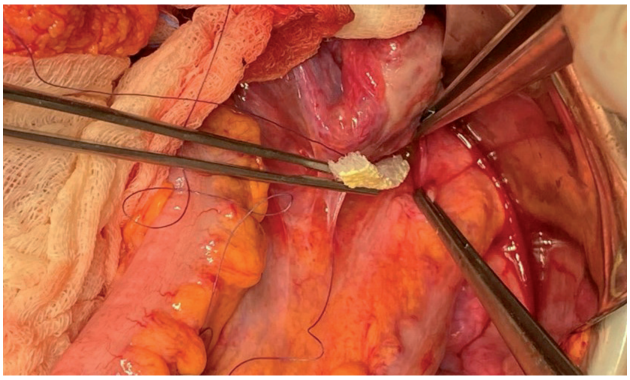


Image 8: Application of small piece of TachoSil® on the defect.

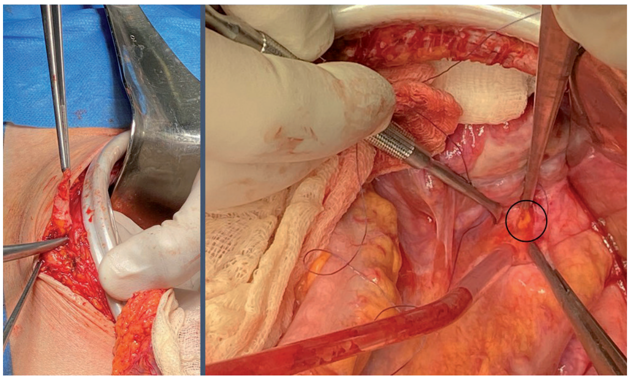


Image 9: Harvesting of muscle-aponeurotic-fatty free flap (left) and introduction into the defect (right).

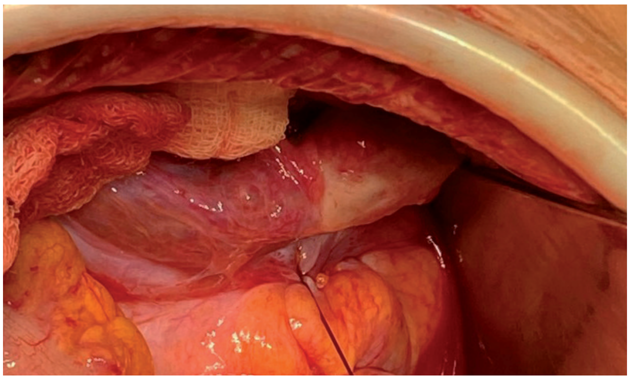


Image 10: Tobacco pouch closure of posterior parietal peritoneum.

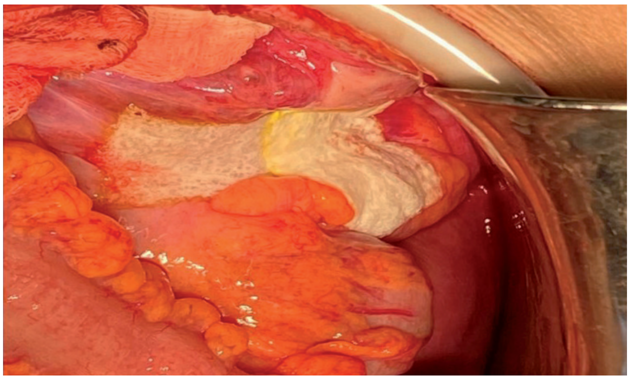


Image 11: Extension of a patch of TachoSil® over the aforementioned tobacco pouch closure.

The defect was covered with a small piece of the TachoSil® hemostatic sealant patch *(→ Image 8)* that was reinforced with a small autologous free muscular-aponeurotic-abdominal fatty flap easily available due to the approach *(→ Image 9)*, with posterior closure of the posterior parietal peritoneum in the tobacco pouch *(→ Image 10)* previously identifying the ureter, and adjacent iliac vein to prevent its inclusion it in the suture. Once the defect was closed, the peritoneal surface was reinforced with a new, larger patch of TachoSil® *(→ Image 11)*.

Various induced Valsalva maneuvers were performed by the anesthesiologist with the objective of increasing the intraabdominal pressure, not identifying new accumulation of CSF stained with fluorescein, terminating the intervention after closure by planes. Intraabdominal postsurgical drainage was not used.

During the postoperative period, the patient was maintained in the decubitus position with external lumbar drainage connected to an exit and Liquoguard® pressure measuring control system that was removed four days after the surgery. The drainage exit opening exhibited drainage of CSF, but ceased with a monofilament stitch without further incident. The patient showed clinical improvement upon discharge with less headache, greater tolerance to decubitus, and progressive improvement of strength in the lower limbs.

Discussion

The anterior sacral meningocele is a rare pathology. The development of the meningocele is a consequence of the pulsatility of the CSF, that erodes the already weakened walls of the spinal canal, in the context of a sacral spinal dysraphism, leading to the prolapse of the meningeal coverings. The anterior sacral meningocele is an entity habitually diagnosed in young patients, around the second and third decades of life, predominately in female. Most cases occur sporadically, although they can occur in the context of syndromes such as type I neurofibromatosis, Marfan syndrome or the Currarino syndrome (anorectal malformations, sacral defects and presacral masses). A familial form of autosomal dominant inheritance is accompanied by tethered marrow, lipomas and teratomas.

The presentation of the anterior sacral meningocele is quite variable. In general, those of a small size tend to be asymptomatic, in which case their diagnosis tends to be incidental. The effect of the mass on the pelvic organs associated with meningoceles of a larger size justifies symptoms such as constipation, pollakiuria, urinary incontinence, dysmenorrhea, dyspareunia or low back pain. The traction of the nerve roots can also cause cyatalgia, reduction of rectal tone and of the bladder detrusor or sensitive alterations in inferior sacral dermatomas. In addition, and as in the aforementioned case, it can cause a rupture of the meningocele with the consequent CSF fistula and the intracranial hypotension. Other infrequent forms of presentation include bacterial meningitis (due to communication of the CSF with enteric structures) and include death due to massive spontaneous ruptures of the meningocele.

Magnetic resonance imaging is the appropriate technique for identifying of anterior sacral meningocele. It provides detailed information about the shape, size and relationship to nearby structures in a quick, safe and non-invasive manner.

The management of anterior sacral meningoceles include observation and follow-up with images of asymptomatic patients with small sized meningoceles, or surgical intervention for symptomatic patients, meningoceles with progressive growth or women of child bearing age with gestational desire and meningoceles of significant size.

Diverse approaches for the treatment of the lesion exist, whose common objective in all of the cases is the disconnection of the dural sacral with the cele through the pedicle that connects them, and the emptying of the latter. The aforementioned approach tends to be indicated in large size defects because it permits excellent visualization, in patients without associated neural defects and requires, in general, a multidisciplinary approach with general surgery. The posterior route tends to be indicated due to the simplicity of the approach in cases of small meningoceles and more distal, with associated neural malformations (for example, anchored medulla) and in anorectal malformations, since it permits their possible repair during the same surgery.

In the case of CSF fistula associated with anterior sacral meningocele in which an evident pedicle is not identified, the objective of the surgery should be the exploration and localization of the defect, as well as its repair and closure of the fistula. To do so, we consider the combination of an autologous tissue (fascia, fatty or muscle) with a synthetic sealant such as TachoSil® (collagen matrix covered with the coagulation factors of human fibrinogen and thrombin) to be optimal, since it permits the watertightness of the meningocele from the first moment.

Moreover it is important to point out the relevance of the intrathecal fluorescein injection since it permits the identification of the defect through which the CSF leaks, which would be very difficult to identify in the absence of this contrast medium. Likewise, it has been demonstrated that the use of an external lumbar drain that permits the derivation of the CSF to be useful to assure an adequate closure of the defect in the immediate postoperative period.

Conclusion

The anterior sacral meningocele is a rare pathology. A detailed study and multidisciplinary approach for each case to determine the best possible decision is fundamental. Different management options include observation or excision through different approaches (anterior and posterior) and techniques (open surgery, endoscopy). In the case of patients with CSF fistula in the context of anterior sacral meningocele without an apparent pedicle, the surgical objective should be the closure of the defect with autologous tissue (fat/fascia/muscle) reinforced with an active sealant patch (TachoSil®). The intrathecal injection of fluorescein and the use of external lumbar drainage are of great utility for the intraoperative identification of the fistula and to ensure the correct closure of the defect in the immediate postoperative period, respectively.

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3

Repair of cerebrospinal fluid fistula in the pleural space after incidental dural opening during dorsal arthrodesis in a patient with spinal tuberculosis

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ABSTRACT: Spinal tuberculosis has serious social and sanitary consequences. Surgical treatment is recommended in cases with neurological involvement or instability, being a challenge given the possible complications. The cerebrospinal fluid fistula can be difficult to treat due to the location and negative pressure in the pleural space. In these cases, indirect techniques for closure and sealing should be considered.

Introduction

Tuberculosis has an increasing incidence in recent decades and with important psycho-sanitary consequences[1]. The most common form of tuberculosis is the vertebral form in the extra pulmonary location, representing from 1 – 3 % of all cases of tuberculosis. Surgical treatment is considered in cases of neurological deterioration, progression or instability, being a challenge given the characteristics of the lesion, the illness and the risks.

The cerebrospinal fluid (CSF) fistula is one of the possible complications of spinal surgery, with an incidence of 2 – 5 %. Due to the location and the negative pressure of the pleural space, the closure of the same can be complicated. When direct suturing is not possible, indirect techniques must be considered for sealing it.

We present a case of dorsal tuberculosis with neurological alteration and progressive kyphosis treated satisfactorily using 360° arthrodesis with fistula complication in the pleural space and sealed with TachoSil® and intercostal muscle flaps.

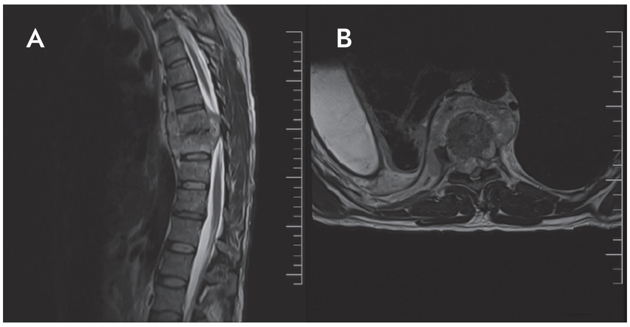

Image 1: A: MRI in sagittal slice **B:** Axial MRI where the T8 – T9 spondylitis is observed with para-vertebral abscesses and invasion of the canal, with severe stenosis and spinal cord compression, without signs of myelopathy.

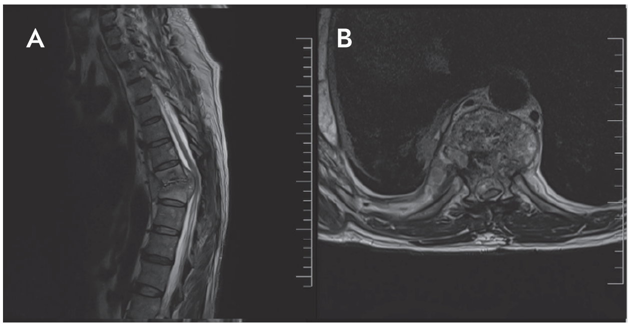

Image 2: A: MRI in sagittal slice **B:** Axial MRI where the T8 – T9 spondylitis is observed with greater bone destruction and hyperkyphosis. It associates revertebral and epidural collections with severe stenosis and compressive myelopathy.

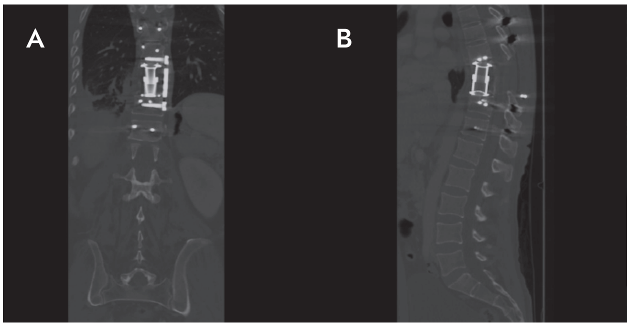

Image 3: CT where properly placed arthrodesis material is observed, without other complications.

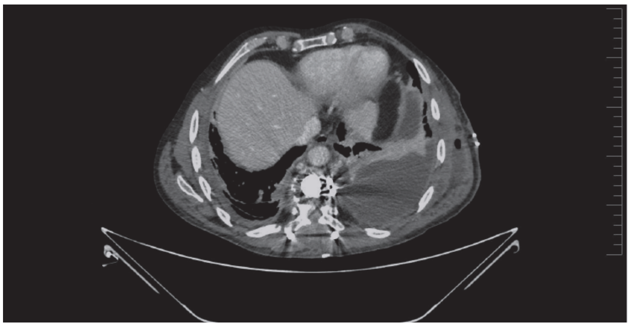

Image 4: CT where a properly placed artefact of arthrodesis material is observed with increased loculated left pleural effusion.

Clinical case

Patient of 48 years of age, native of Marrakesh comes to the emergency department due to symptoms of dorsalgia with progressive irradiation to the left inferior member for the last six months, accompanied by the sensation of a motor deficit. Physical examination present hyperreflexia in the inferior extremities, with an increase in the reflexogenic area and bilateral adduction evocation in both patellar and Achilles reflexes. The loss of strength in the right inferior extremity 4/5 at the level of the quadriceps and in the left inferior extremity 4/5 in quadriceps and flexor-extension of the right foot, with minimum claudication in Mingazzini could be shown.

A dorsal magnetic resonance image (MRI) was performed *(→ Image 1)* where signs of spondylitis at the T8 – T9 level were observed, with multiple paravertebral abscesses with invasion of the canal causing severe stenosis and spinal chord compression, without evident signs of myelopathy. A large size cavity in the right pleura with consolidation in the posterior basal region of the right lower lob could be seen.

Given the diagnosis and progressive neurological effect a T8 – T9 laminectomy and flavectomy were performed taking samples and inserting a thoracic tube. Microbiological analysis demonstrated an infectious tuberculosis sensitive to front line tuberculostatic treatment, so medical treatment was initiated and later hospital discharge after improvement with rehabilitation treatment. Afterwards, the patient changed the city of residence, where the antituberculostatic treatment was discontinued.

Six months later, the patient returned due to a clinical case of ten days of evolution of dorsolumbar and left knee pain accompanied by weakness in the lower extremities, as well as urinary and fecal incontinence of three days evolution. Physical examination revealed pain on palpation of the lumbar musculature with hypoesthesia in inferior extremities and perineum, with muscle strength 3 – 4/5 and exaggerated osteotendinous reflexes. A new MRI of the dorsal spine *(→ Image 2)* was performed where T8 – T9 spondylitis tuberculosis was observed, where greater bone destruction and hyperkyphosis was evident when compared to the prior study. Presentation of prevertebral and epidural collections (10 x 57 x 90 mm and 10 x 24 x 62 mm, respectively) with severe stenosis of the canal and signs of compressive myelopathy.

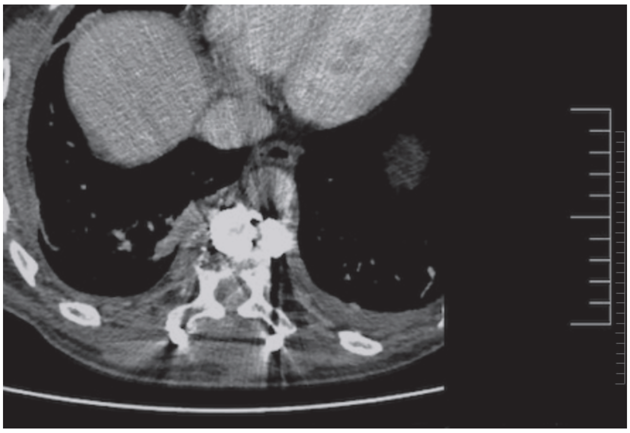

Image 5: CT where resolution of the left pleural effusion is observed, with air content and secondary enhancement of postsurgical changes.

Given the diagnosis and evolution, the thoracic surgery service decided on surgical intervention through a left D8 – D9 thoracotomy, with access to the left hemithorax. A D8 – D9 corpectomy was performed identifying dural sac upon which a minimal tear was produced, that was unable to be sutured so it was sealed using a dural patch (DuraGen, Integra LifeSciences Corporation, Plainsboro, NJ) and a hydrogel sealing agent (Tissucol, Baxter Healthcare Corporation, Ltd). An expansive cylinder with distraction and TSLP plate were implanted with screws at D7 and D10. In the same intervention posterior arthrodesis with transpedicular screws from D6 to D11 was performed. Pleural drainage against gravity was maintained. During the postoperative period a CT was performed where postsurgical changes were observed with correct placement of the arthrodesis material and small left paravertebral pile *(→ Image 3).*

Evolutionarily drainage of clear liquid congruent with CSF was observed in the thoracic tube, with posterior swelling in the thoracotomy for which a new imaging study was performed with a thorax CT where increased loculated left pleural effusion was observed, with signs of superinfection *(→ Image 4).* No respiratory deficit nor saturation alterations were observed.

Given the diagnosis it was decided to re-open the left thoracotomy to identify the pleural cavity with an important accumulation of CSF. A fistulous orifice was identified which was not accessible to be sutured so it was sealed in layers. First TachoSil® (Corza Medical) was placed in several layers and Tissucol. Afterwards a pediculated muscle flap was obtained from the intercostal muscle that was applied in the surgical zone using a rotational maneuver and was attached to the parietal pleura. During the surgery a thorax tube and external lumbar drain (ELD) were inserted with a drainage output of 8 – 10 ml/hour. After five days of rest the patient began mobilizations, lumbar drainage was removed and it was decided to remove both drains at even days, without observation of complications.

A CT was performed *(→ Image 5)* which showed the reduction of the left pleural effusion, with air bubbles in its interior and pleural enhancement, probably postoperative. Increase of the soft parts of the left thoracic wall the thoracic area.

The patient evolves favorably and continues with the infectious treatment with tuberculostatic therapy.

Discussion

Tuberculosis is one of the oldest illnesses in the world, and its incidence is increasing[1]. Despite the effectiveness of the treatment and social economic improvement the increase of HIV and immigration make it a worldwide public health problem[1]. The extra pulmonary disease occurs in 15 – 20 % of the cases, and of these vertebral tuberculosis is the most common form, as a result of the hematogenous spread from a primary focus usually pulmonary[3]. The infection reaches the spine through the arterial vascular canals, through the Batson venous plexus, later disseminating through the longitudinal ligament of the adjacent vertebral bodies[1].

With respect to the treatment of spinal tuberculosis, controversy exists regarding the need for surgical treatment. A review by Jutte et al.[4] no statically significant differences are observed in the evolution of the patients with medical or surgical treatment, although in the majority of them surgical treatment was performed.

A neurological deficit is the most severe complication of spinal tuberculosis, which can be caused in two states: early paraparesis, which occurs due to soft pressure secondary to pus, necrosis or granuloma and leads to a slow and gradual compression and is late paraparesis, due to rigid pressure, principally due to kyphosis or granulomatous scar[5]. Some authors have suggested that even early paraplegia could be improved or cured with medical treatment[6]. However, various authors pointed out the possibility of irreparable damage due to conservative treatment[7,8].

According to the Gulhane Akeri Tip Akademisi (GATA) classification[9], the surgery must be considered in those patients with uncontrolled pain due to collapse or deformation (type III), neurological deficits (type II and III) or clinical or radiological progression in spite of antituberculostatic treatment (Type IA).

In our case, given the initial presence of neurological alteration and vertebral abscesses, as well as the good results described in recent years with unique posterior surgical treatment[10], it was decided to perform a laminectomy to decompress the spine to improve the patient's clinical condition, maintaining medical treatment as the principal therapy.

However due to the patient's lack of adherence to the medical treatment the patient appeared to have worsening of the radiological kyphosis and clinical deterioration, so we decided to complete the surgical treatment by an extra pleural thoracotomy and anterior approach, with corpectomy for decompression and box fusion, followed by posterior transpedicular instrumentation.

Choosing surgery is often a challenge, which is why individual studies of each case are essential. According to various authors and the evolution in recent years[11], if after a posterior surgery a correct drainage and evolution is not obtained, an additional anterior surgery should achieve an improved evolution. The anterior approach, according to the literature[12,13] permits an improved debridement and correction of kyphosis.

Among the arguments against surgical intervention are possible complications. The CSF fistula is one of them, especially in the anterior approaches to the thoracic spine[14]. It is a serious complication because, although the best treatment is direct suturing, the narrow canal and the location make doing so a challenge. The treatment through a thorax tube and lumbar drainage can be sufficient in small caliber fistulas[15], but the presence of negative pressure in the pleural space (-5 to -7.5 cm H_2O) with respect to the arachnoid space (+10 to +15 cm H_20) can make spontaneous closure difficult[15-17].

The use of TachoSil® is indicated in adults as a hemostatic treatment or dura mater sealant to prevent cerebrospinal fluid fistulas[18,19]. Simular to cases[15,16] a second surgery was necessary. In spite of the localization difficulties, as well as the negative pressure in the pleural space which makes closure of the same difficult, the use of a patch in various layers, along with an intercostal muscle flap was able to resolve the problem satisfactorily. Additional measures such as lumbar drainage and bed rest help to reduce the CSF pressure and repair the defect.

Conclusions

The therapeutic management of spinal tuberculosis can be complicated. Surgical treatment should be considered in those with neurological symptoms, instability or deformation, concomitant with prolonged medical treatment. In the case of the complication of pleural CSF fistulas they can be sealed using a triple layer of TachoSil® and intercostal muscle flap, connected to a chest tube and lumbar drainage, given the persistence of the same because of the negative pleural pressure.

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4

Microvascular decompression using a retrosigmoid approach in a patient with hemifacial spasm using TachoSil® as a dural sealant

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Introduction

Hemifacial spasm (HS) is a disorder of the movement of the cranial nerve (cn) VII characterized by the involuntary contraction of the musculature innervated by this nerve. The natural evolution in 90 % of the cases is clinical progression. In most of the cases primary HS is identified by an aberrant or ectasic vessel that compresses the nerve at its apparent exit zone leading to its demyelination. Its treatment includes pharmacological measures, botulinum toxin injections and surgical microvascular decompression. Surgery is the only therapeutic method that can offer a complete cure in up to 90 % of the cases[1,2].

Among the principal complications we found the recurrence of the disease, hypoacusis, facial paralysis (transitory or permanent), lesion of lower cranial nerve pairs, intracranial hemorrhage, cerebral edema, venous sinus thrombosis and cerebrospinal fluid (CSF) fistula (2 – 3 %)[3].

The CSF fistula can cause infectious complication of the central nervous system (CNS) or suppose the need for reintervention. We present a case of a patient with HS utilizing TachoSil® as a dural sealant material in a posterior fossa surgery.

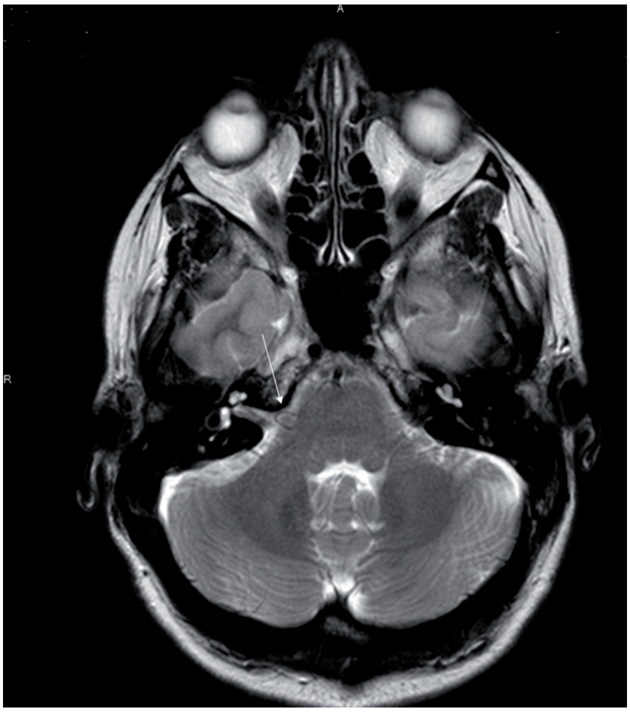

Image 1

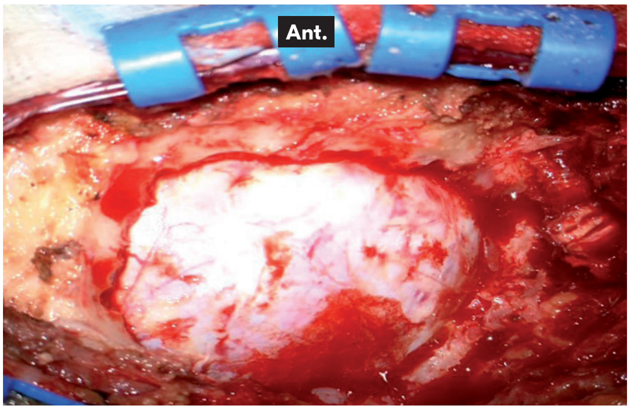

Image 2

Clinical case

We present the case of a female of 41 years of age suffering from right HS with five years of evolution, resistant to treatment with botulinum toxin. In the imaging tests a vascular loop that enters the third proximal ipsilateral internal auditive conduct is seen without being able to identify vascular pressure *(→ Image 1)*. In the presurgical neurophysiological study the presence of "Lateral Spread Response" (LSR) is demonstrated.

Microvascular decompression of the right cn VII was performed using a right retrosigmoid approach. An incision is made in the skin, behind the right ear, in the shape of an inverted "U" and, after the dissection of the musculature, a retromastoid craniotomy *(→ Image 2)* is performed, with posterior durotomy in "Y", with bases towards the sigmoid sinus and transverse sinus. The cisterns are emptied with the consequent drainage of CSF, which is responsible for the relaxation of the cerebellar parenchyma. An offending vessel parallel to the cn VII was objectified *(→ Images 3A and 3B)*. With their separation, the CSF phenomena disappeared, so teflon was placed between both structures *(→ Image 3C)*. It was verified that no other structures that compress or have contact with the cn VII exist. To perform a hermetic dural closure, a dural plasty was placed *(→ Image 4A)*; afterwards, the dura mater was sutured using silk stitches *(→ Image 4B)*; it was covered with two layers of TachoSil® achieving total coverage of the retrosigmoid craniotomy surface *(→ Images 4C and 4D)*. Finally, the bone flap was replaced fixing it with titanium mini-plates and suturing the soft parts by planes.

After the surgery the patient presented complete resolution of HS as well as clinical transient peripheral dizziness. During the postoperative period and in the posterior follow-up of six months the patient did not present clinical signs of CSF fistula with the surgical wound remaining without staining or palpable build-up *(→ Image 5)*. In the postsurgical neurophysiological examination no recurrence of CSF was observed.

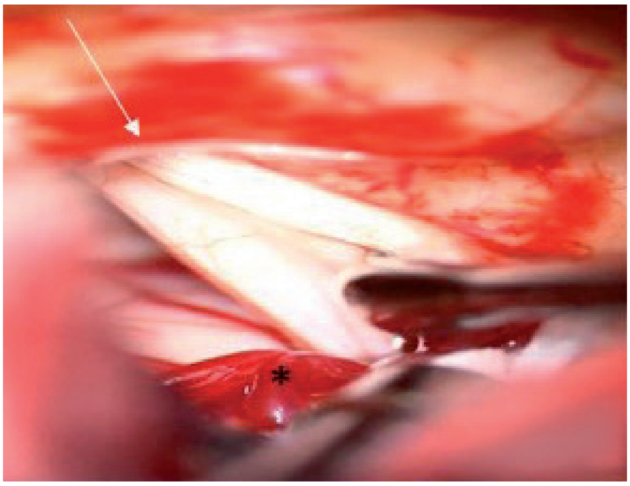

Image 3A

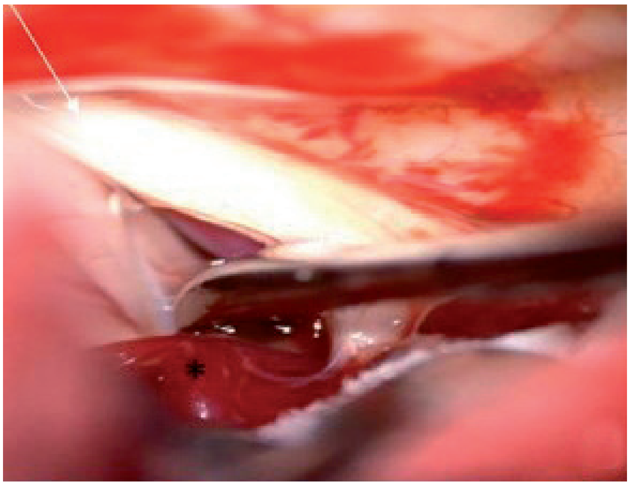

Image 3B

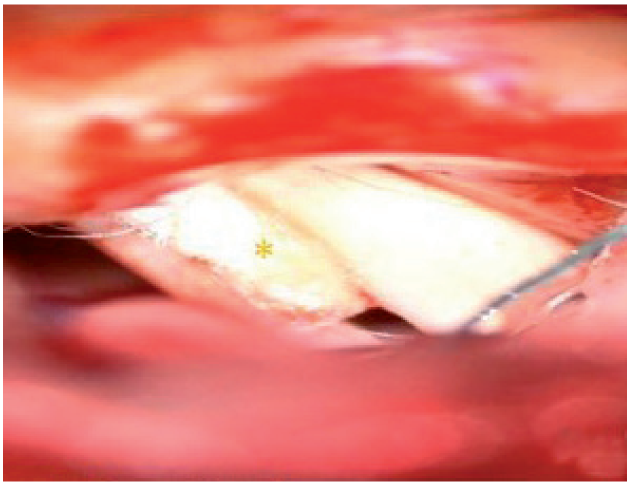

Image 3C

Discussion

The first case of HS that we find in the literature was described by Schultze who, in 1875, presents a case of a middle age male with involuntary contractions of the left facial muscles finding in the autopsy an aneurysm of the left vertebral artery that compressed the left VII cn. It was in 1886 when Gowers described the clinical syndrome that would be denominated as "hémispasme facial périphérique" (hemifacial spasm), in 1905 by Babinski[1]. In 1975 Janetta proposed vascular compression in the apparent exit zone of cn VII as the ethology of this entity and presented the surgical treatment for HS[4].

The prevalence of HS appears to be higher in women (14.5/100,000 inhabitants) than in men (7.4/100,000 inhabitants), and in the Asian population, between the 5th and 6th decade of life. It tends to be sporadic and unilateral (bilateral in <1 % of cases), starting with the contraction of the orbicularis oculi muscle typically manifested by the raising of the eyebrow. Afterwards, the contractions start to affect the inferior part of the facial muscles and, eventually, the platysma.

Patients with this pathology can hear a paroxysmal clicking due to the contraction of the stapedius muscle[1,2,4]. This pathology causes a disability that jeopardizes social, professional, and personal aspects of the patient's life, potentially leading to functional blindness and social isolation[2].

For diagnosis it is necessary to perform a magnetic resonance imaging that discards structural lesions and proves the existence of a vascular loop that may be compressing the cn VII. The electrophysiological diagnosis is characterized by the presence of the diffusion of the blinking reflex to different orbicularis oculi muscles (LSR). This phenomenon helps the surgeon determine if an adequate decompression of the cn VII exists since it disappears or is markedly reduced when separated from the aberrant vessel[1,6].

Among the therapeutic options are pharmacological treatment, botulin toxin injections and surgical microvascular decompression, with the latter currently being the only treatment at the moment[1,6]. The efficacy of the microvascular decompression is high and consistent in the literature (85 – 90 % success), with a low rate of reincidence after years of follow-up[2].

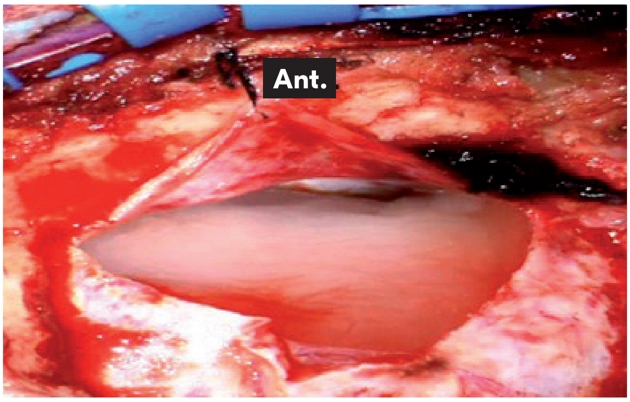

Image 4A

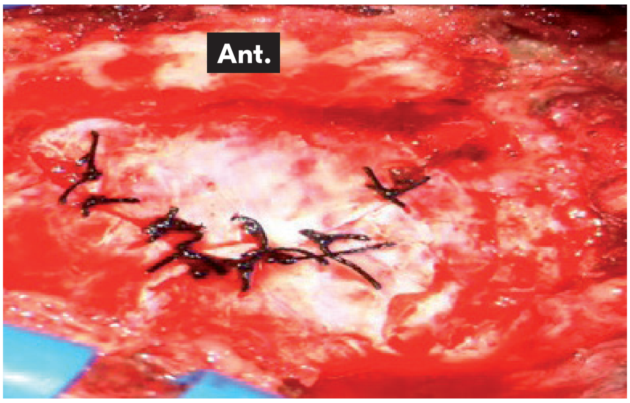

Image 4B

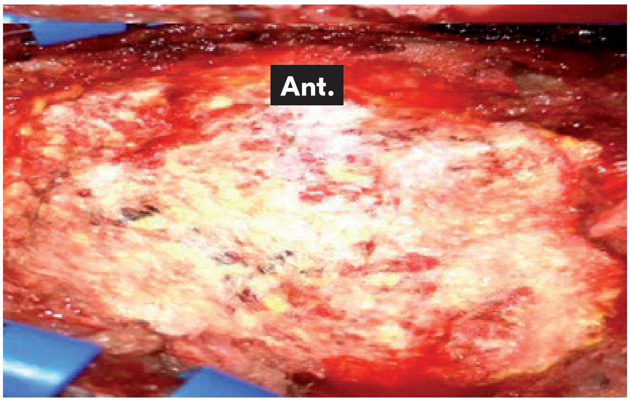

Image 4C

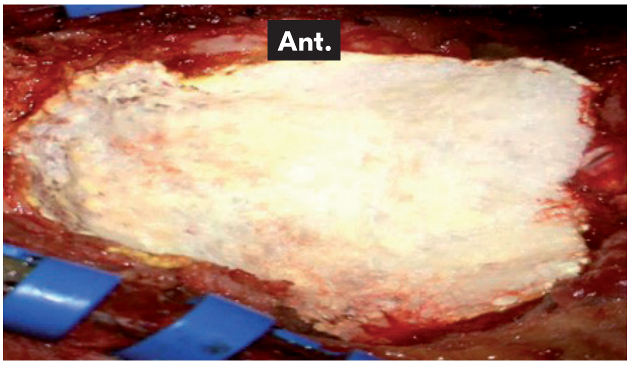

Image 4D

Among the possible complications of this surgical approach are CSF fistulas, which can also lead to infectious complications both local and to the CNS including potentially severe infections such as secondary meningitis. The presence of CSF leakage significantly increases the postoperative morbidity, the hospital stay and the associated sanitary costs[1,5,7]. The percentage of CSF leakage in posterior fossa surgery described in the literature varies from 2.5 % and 10 % of the cases[3,7], being higher at the beginning of the learning curve. Once this curve stabilizes, the probability can decline a much as 1 – 2 %[3], Although an established "gold standard" technique doesn't exist for the dural sealing[7], the sandwich closure of the dura mater significantly reduces the probability of CSF fistula[5]. The surgical technique, an adequate hermetic dural seal as well as an efficient sealing of the mastoid cells if an opening is produced, diminish the possibilities of posterior CSF fistula. The leak of CSF and its related complications can, therefore, be reduced to a reasonable rate, less than 2 %, as long as the closing techniques are carefully applied[3,5].

According to TachoSil®, its efficacy as a dural sealant has been evaluated through randomized and controlled studies of patients, who have undergone cranial base surgery: however its superiority with respect to the previously mentioned habitual technique has been documented. However, its secure use as adjuvant has been determined, with its application over the dura mater, as well as a similar efficacy to that of other dural sealing techniques in habitual clinical practice[7,8].

Performing an adequate hermetic dural seal, that diminishes the probability of suffering a CSF fistula, is a laborious task and, in some cases, impossible to carry out exclusively by suturing the dura mater. TachoSil® diminishes the incidence of hemorrhagic complications at the local level[9].

In addition, it is a quick and efficient method to perform an adequate dural closure. Its safe use in the neurological patient has already been proven[8,9], and its use does not appear to alter the natural healing process[9]. In this manuscript, we present the case of a patient with HS treated surgically with microvascular decompression in which TachoSil® is used as a dural sealant, with positive subsequent results.

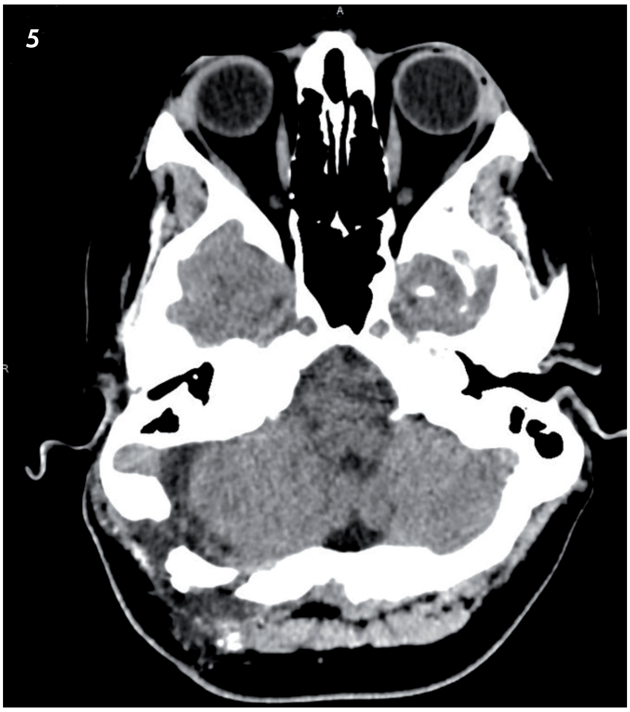

Image *5*

ABBREVIATIONS

HS: Hemifacial Spasm
CSF: Cerebrospinal Fluid
LSR: Lateral Spread Response
CN: Cranial Nerve
CNS: Central Nervous System

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5

Periventricular tumor and surgical sealing of the ventricle

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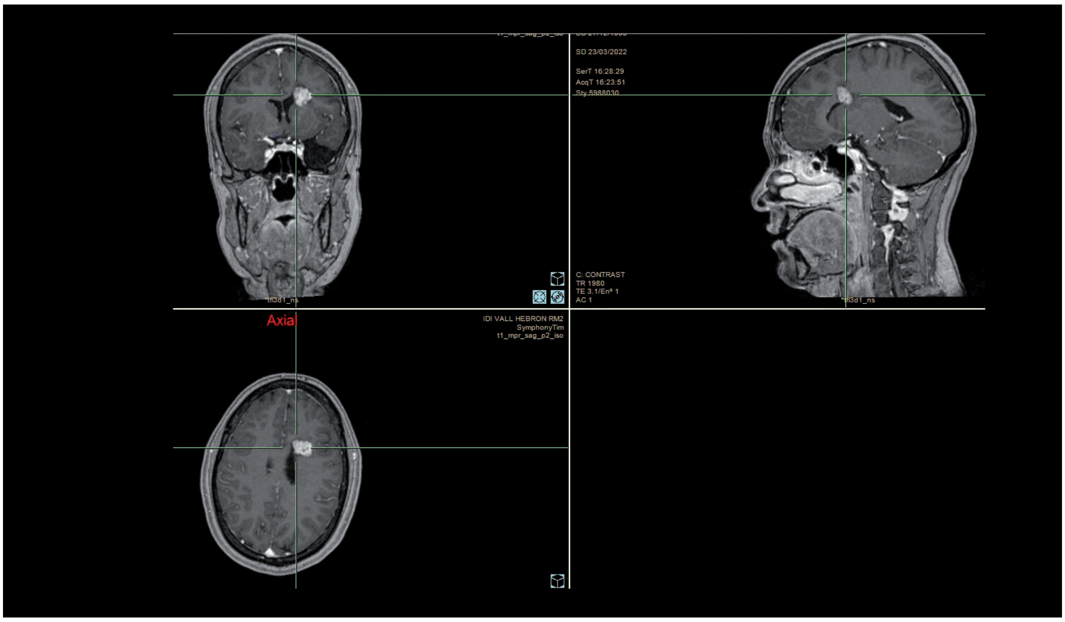


Image 1: Presurgical MRI (T1 sequence with contrast): intraparenchymal tumor located in the white substance of the left frontal periventricular.

Introduction

In neurosurgery it is frequently necessary to open the intraventricular space for the resection of lesions found in the periphery of the ventricular system or inside of it[1]. After the opening of the ventricular space, an adequate closure is required to prevent postoperative cerebrospinal fluid (CSF) fistula, a frequent complication that increases the risk of postoperative meningitis and requires diverse techniques for its repair[2,3].

In our center we use a matrix designed for sealing and hemostasis (TachoSil®), with very good results. We present a case to show the medical use of this and the postoperative results.

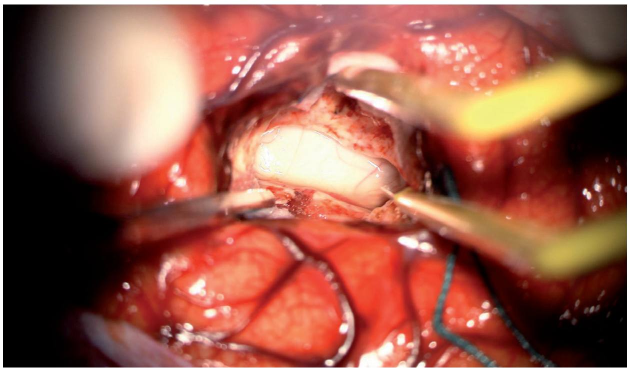


Image 2: Intraoperative view of open left lateral ventricle after tumoral resection. Left frontal transcortical approach.

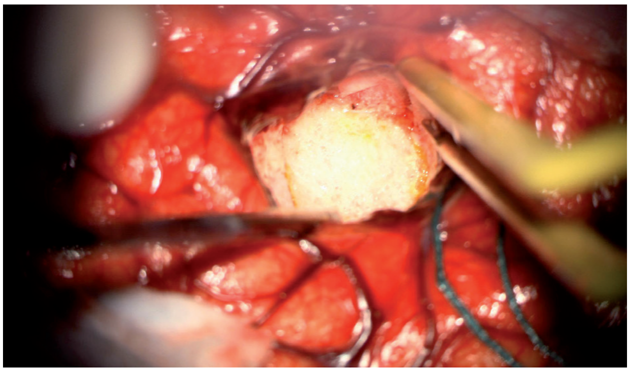
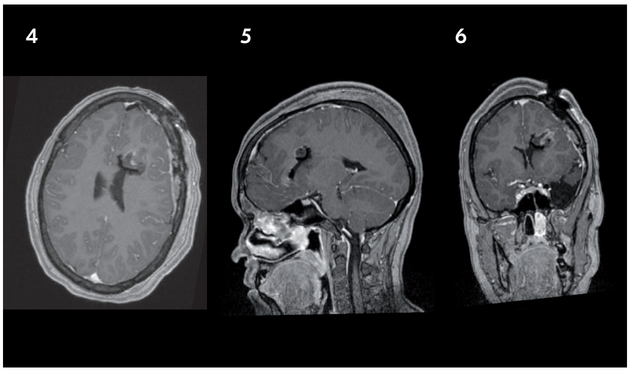


Image 3: Intraoperative view of hermetic sealing of the ventricular system after placement of TachoSil®.



Images 4, 5 and 6: Postoperative MRI (T1 sequence with contrast) axial, sagittal, and coronal cuts: Complete surgical resection of the lesion can be seen as well as the adequate sealing of the ventricular system through using TachoSil®.

Clinical case

It concerns a 24 year old female, that due to symptoms of headaches and dizziness a cerebral MRI is performed in which can be observed an intraparenchymal tumor located in the white substance of the left frontal periventricular, that from its radiological aspect suggests relation to a primary lymphoma of the CNS (central nervous system) *(→ Image 1)*. The extended study did not include extracranial lesions.

Based on this presumptive diagnosis a biopsy was performed for diagnosis and posterior treatment of the lesion. The result of the anatomical-pathological analysis was intracranial Schwannoma. Since this is a very unusual diagnosis[4,5,6] a second opinion was requested from an external center, who reported that it was a grade I pilocytic astrocytoma.

Due to the variety of diagnoses obtained, the patient is offered the possibility of a complete surgical resection of the lesion.

The surgical intervention is performed with neurophysiological motor pathway monitoring, obtaining a complete resection with integrity of the path. The left lateral ventricle is opened *(→ Image 2)* with the consequent emptying of CSF. After the complete resection and correct hemostasis, proceed to close the ventricle by using TachoSil® as a sealing matrix *(→ Image 3)* achieving a perfect intraoperative seal without signs of fistula.

In the postoperative process the patient did not present complications nor signs of CSF fistula.
A postoperative MRI was performed in which complete resection of the lesion was observed as well as the correct sealing of the left lateral ventricle, distinguishing the application of the sealing material in the magnetic resonance imaging *(→ Images 4, 5, and 6)*.

Discussion

The complexity of a postoperative resolution of a cerebrospinal fluid fistula, makes it necessary to maximize intraoperative precautions to prevent this complication. Sometimes, multiple techniques are required for its repair (review of the surgical wound, lumbar drainage punctures, placement of external lumbar drainage or permanent bypass systems, including use of skin flaps for wound repair, etc.)[3,7]. For this reason, diverse centers perform different types of techniques to achieve the correct hermetic seal of the ventricular system[4,5,6].

Based on our experience, we propose the routine use of TachoSil® as a hermetic sealant of the ventricular space after its surgical aspiration, that has been demonstrated to be a secure procedure with very good results.

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6

Combined triple dural closure in lumbosacral tumor: collagen dural patch, fibrinogen and thrombin adhesive matrix and fibrinogen and thrombin adhesive

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Introduction

The treatment of intradural spinal tumors is based on a complete surgical resection whenever it is technically possible.

One of the major problems of this surgery is the closure of the dura mater, which is very difficult or not inviable on occasion due to the tumor infiltration. Likewise, due to its disposition the anterior or lateral defects, can be impossible to suture.

An inadequate closure can provoke a CSF fistula. For all of these reasons the use of sealing patches and medicated matrices, that help in the dural closure are widely extended in spinal surgery.

We present a case of a 51 year old patient intervened for a an intradural extramedullary tumor in which it was impossible to perform a dural closure by direct suture, so a triple combination closure was performed using a collagen dural patch, a fibrinogen and thrombin adhesive matrix and a fibrinogen and thrombin adhesive. The postoperative results were satisfactory, without evidence of complications during the closure.

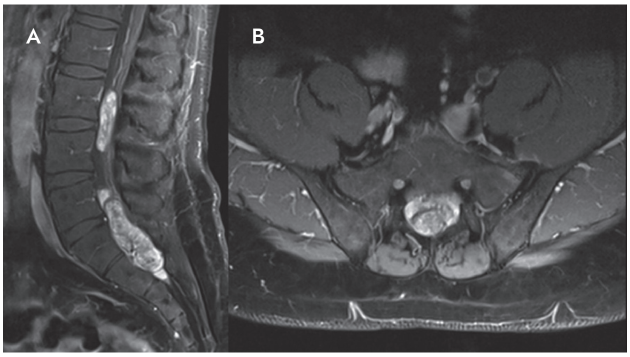

Image 1: Presurgical lumbosacral MRI. **A:** T1 sagittal slice where two intradural lesions are seen, one at level L3 — L4 and the other at L5 — S3. Highlights the moderate and heterogeneous contrast uptake of both. **B:** T1 axial slice at the level of the L5 — S3 lesion. The heterogenous uptake of the contrast is observed and how the roots of the cauda equina are found embedded by the tumor.

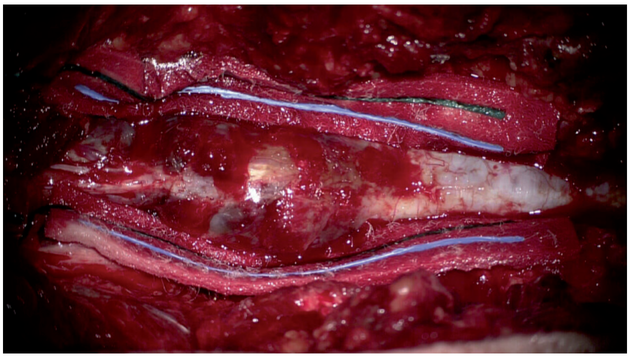

Image 2: Intraoperative view of the L5 — S3 lesion prior to the dural opening. A weak dura mater is observed, even disintegrated at some point, that is intimately adhered to the tumor.

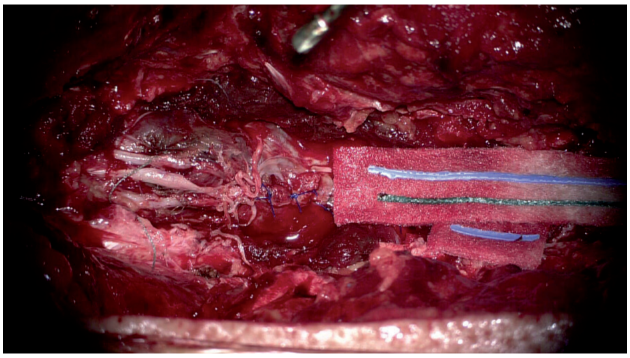

Image 3: Intraoperative view of the L5 — S3 lesion after the resection. In the central part closure by suture can be observed. To the left of this are observed the roots of the cauda equina wrapped in the tumor, in addition to completely disintegrated dura mater, in which it is impossible to perform a closure by direct suture.

Clinical case

The case presented is a 51 year old patient that due to an episode of pain in the buttocks a lumbosacral underwent magnetic resonance imaging (MRI), where two intraspinal masses are observed, the first at level L3 — L4 and the other at L5 — S3, hyperintense in T1 and T2, with moderate and heterogeneous intravenous contrast uptake, and radiologically compatible with tumors of neural lineage.

In the assessment of the neurosurgery consultation, a clinical improvement was noted, with remission of the buttock pain. Physical examination was completely normal, and neurophysiological study shows no alterations.

Surgery was recommended, but the patient initially prefered to wait. Reassessed six months later, he complained feeling worse everyday, with increasing limitations when changing posture, clumsiness when walking, constipation problems and difficulty in initiating urination.

A new lumbosacral MRI was performed *(→ Image 1)* which showed no significant changes to the previous one, but given the clinical evolution it was decided to perform surgical intervention.

An L3 — S3 laminectomy was performed, initiating the resection in the sacral lesion *(→ Image 2)*. After performing the dural opening, a dura mater intimately adhered to the tumor, and of a very fragile consistency was identified. A complete dural opening was obtained and, after partially resecting the lesion due to the high risk of a complete resection, the lumbar lesion was resected.

This lesion was not adhered to the dura mater, having a normal consistency, so a partial resection was also performed due to the high risk of lesion to the lumbosacral roots.

After hemostasis was achieved, dura was closed. In the lumbar lesion there were no difficulties to perform a direct suture closure. However, the sacral lesion presented a very weak dura mater, in some areas it was absent *(→ Image 3)*.

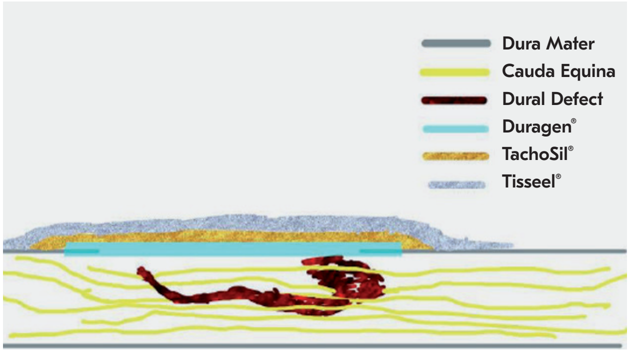

Image 4: Combined triple dural closure scheme. A collagen dural matrix is placed and covering the dural defect, on top of this, the fibrinogen and thrombin adhesive matrix and covering everything a fibrinogen and thrombin adhesive is applied.

In the favorable areas the closure was with direct suture. In the area where the dura mater was more deteriorated it is decided to apply the triple combination of *(→ Image 4):* dural collagen patch (Duragen®), fibrinogen and thrombin adhesive matrix (TachoSil®) and fibrinogen and thrombin adhesive (Tisseel®). In addition, a lumbar drain was implanted above the L3, the lumbar laminas were replaced with mini-plates and screws and an exhaustive closure by planes was carried out.

Postoperatively the patient remained in supine decubitus position, and with the lumbar drainage with an output of 200 – 250 ml per day during three days. Afterwards it was removed and he began wandering without registering incidents. The surgical wound showed a good appearance, without psuedomeningocele or any other complication.

Discussion

Intradural spinal tumors, both intramedullary and extramedullary, tend to have benign characteristics, whose treatment is based on a complete surgical resection whenever it is technically possible. One of the major problems of these surgeries is cerebrospinal fluid (CSF) fistula, with an incidence ranging from 3 % to 20 % in the literature. In fact, outside of tumoral surgery, the incidence of CSF fistula in spinal surgery ranges from 5.5 % to 9 % in primary surgery, increasing to 13.2 – 21 % in revision surgeries[1].

This complication can ruin the postoperative spinal surgery. The symptoms vary, but include: headache, nausea, vomiting, pain, pseudomeningocele, infection of the surgical site, meningitis or even spinal abscesses.

After so many years, direct suturing continues to be the gold standard for dural closure, especially in posterior defects. Nonetheless, the anterior or lateral defects, due to their disposition, can be impossible to suture, which is why the use of patches is widely extended in spinal surgery, especially when dealing with resection of spinal tumors. The use of fascia and autologous fat, fibrin adhesives and diverse types of sealants have been described.

Collagen is chemotactic for fibroblasts, which is why it has been the source for development of the majority of the dural patches. The collagen matrix provides a low pressure absorption surface that permits the diffusion of CSF and is fixed to the dura mater thanks to the superficial tension. The collagen immediately starts the formation of a clot, facilitating the sealing[2]. Following this physiochemical principle the collagen dural patch is applied (Duragen®) over the surface to be covered.

On top of this an adhesive matrix of fibrinogen and thrombin (TachoSil®) is applied. TachoSil® is an absorbable patch, manufactured with equine collagen, covered with human fibrinogen and thrombin, which is widely used in spinal surgery. When it comes in contact with the physiological fluids, its components dissolve and spread over the defect to be sealed. This produces a cascade effect that reproduces the final phase of coagulation. The fibrinogen converts to fibrin that finally will form the clot, which will maintain the matrix on the surface to be sealed. The fibrin reacts with the factor XIII, creating a firm and mechanically stable network, that amplifies the sealing[3].

In a similar way, the addition of the fibrogen and thrombin adhesive (Tisseel®) assists in the appearance of a chemical reaction in which the collagen matrix provides chemical signals for the appearance of fibroblasts, that begin after 3 – 4 days and are stable in 10 – 14 days. The fibroblasts help the pores of the collagen matrix to provide more collagen. Finally, 6 – 8 weeks later, the collagen matrix is reabsorbed and substituted by the new dura mater[2].

These and other different accessories have been used for closure. However, we believe that direct suture is indispensable in the closure of intradural tumors, as long as they are hermetic, and can be performed in a safe way. The collagen matrix will help to improve the dural regeneration.

There are surgeons that recommend the use of fibrin analogues as complimentary to direct sutures, that seem to reduce the risk of CSF fistula. In a survey of experienced spinal surgeons carried out by Oitment et al.[4], there was a significant consensus with respect to the repair of large posterior dural defects, where the majority prefer a combination of direct suture associated with a sealant. The sealant preferred in this case, due to practical and economic factors, was Tisseel®.

Fibrin adhesives are considered effective for the prevention of CSF fistula in neurosurgery in general and in spinal surgery in particular[5]. Kassam et al.[6] argue that the use of these reduces the appearance of postoperative liquorrhea and offers cost-effective benefits.

In some centers closure protocols have been established, but the clinical practice varies substantially depending on the size and location of the dural defect. In the study by Narotam, et al.[2], the use of the collagen matrix (Duragen®) was satisfactory in 95 % of the patients, with a rate of CSF fistula of 1.4 % and of pseudomeningocele of 2.9 %. These results are similar to those compared to the traditional method of direct suture closure.

The major risk of attempting a direct suture closure in small defects is the conversion of low pressure defects in high pressure pores provoked by the suture needles. This could provoke changes in the hydrostatic pressure of the CSF when the transition to orthostatism occurs[2].

In addition to the closure, it may become important to reduce in the hydrostatic pressure of the CSF. Various methods can be used to do so: reduce the formation of CSF, adjust the position of the patient or utilize drainage catheters for CSF.

A hermetic seal of the muscular fascia can increase the pressure in the epidural space, reducing the flow of CSF and facilitating the adhesion of the dural end points. In the meantime, a sub-fascial drain helps to eliminate the dead space[7].

Some authors argue that the lumbar drains, when they are implanted close to the defect, reduce the hydrostatic pressure, thereby helping the healing[4]. Postoperative rest in decubitus position also theoretically reduces the hydrostatic pressure, although the efficacy of this measure has not been as clearly demonstrated.

In some experimental pressure studies[2], the dural defects repaired only with sutures had leaks, while those that had complements such as a fibrin adhesive, tolerated greater hydrostatic pressure. This could support the hypothesis that it is technically impossible to achieve a 100 % hermetic closure with direct suture, being essential to complement it with a chemical sealant to complete the healing.

The use of a blood patch has also been described for the treatment of the CSF fistula, especially in patients with CSF fistula in an unknown location.

With respect to the appearance of the surgical sealants in the postoperative MRI, it is a field that has not been sufficiently investigated. For this reason, it may be confused with hematomas or even with a recurrent herniated disc, which could change the clinical decision. Care must be taken not to use these products in excess, since they can provoke complications associated with a neural compression. It seems to be clear that TachoSil® appears hypointense to CSF and isointense to the T1 and T2 muscle[8].

The commercial fibrin adhesives contain bovine aprotinin, which could cause reticence to their use due to an increased risk of infection. In the series by Montano et. al[1], no adverse reactions were found to be associated to the use of TachoSil®. There was only one case of subcutaneous CSF collection that was resolved with lumbar drainage during 72 hours. The study by Narotam et. al[2] also establishes that the use of collagen products or matrices or adhesives of fibrinogen and thrombin do not increase the rate of infection of the surgical wound.

The repair of established pseudomeningoceles is especially delicate. Normally conservative management is attempted, with the use of lumbar drains associated to bed rest and compress bandages, but these are not always sufficient. When the surgery is necessary, the use of a sandwich of a matrix of collagen/fibrin adhesive was not sufficient in the repair of these defects[2].

Conclusion

The dural closure, when a large defect exists, is one of the challenges of spinal surgery. In the cases where it is not possible to perform a direct suture, the use of thrombin dural patches and adhesives is widely extended.

However, their exclusive use might be insufficient. This is why the triple combination of a dural patch, adhesive matrix and thrombin adhesive produce a synergy of the action mechanisms, amplifying healing and reducing the appearance of CSF fistula in a substantial manner.

In spite of all of this, the most important aspect in the treatment of CSF fistula is prevention. This includes preoperative assessment of the risk of a posterior fistula, in addition to a careful intraoperative manipulation.

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Application of TachoSil® in neurosurgery: presentation of a case and bibliographic review

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Introduction

Since the dawning of civilization, the hemorrhage has been one of the principal challenges faced by ancient doctors. We have proof of this in the "doctors" of Classic Greece and Hellenistic Egypt that introduced the concept of hemostasis. In fact, the etymology of this term stems from the prefix "hemo" from the "αιμο" *(haimo)* or "blood" and "στασις" *(stasis)* that means detention.

Since the beginning of modern neurosurgery, various techniques have been developed to prevent postoperative bleeding and CSF fistulas. The postsurgical costs and morbidity and mortality are influenced mostly by hemorrhages and their consequences. Inadequate management of bleeding can lead to an increase in surgical time, negatively influence the healing of the surgical wound and/or increase the risk of infection.

In the last decade, the advances in biotechnology have resulted in an explosive growth of available topical hemostatic agents. The use of these agents essential to prevent bleeding and to resolve problems intraoperatively and locally.

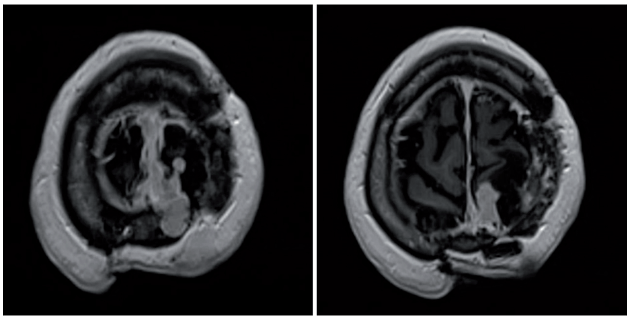

Image 1: Axial slices of the cerebral MRI T1 sequence with contrast. We can observe a recurrent tumor at the left frontal parasagittal, found adjacent to the superior longitudinal sinus, but does not infiltrate nor collapse it.

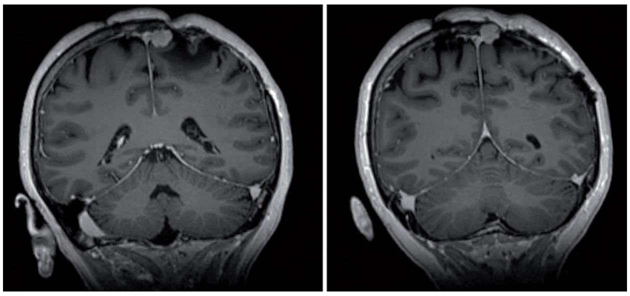

Image 2: Coronal slices of the cerebral MRI T1 sequence with contrast. A residual tumor is observed at the level of the left frontal parasagittal, adjacent to the superior longitudinal sinus, but does not infiltrate or collapse it.

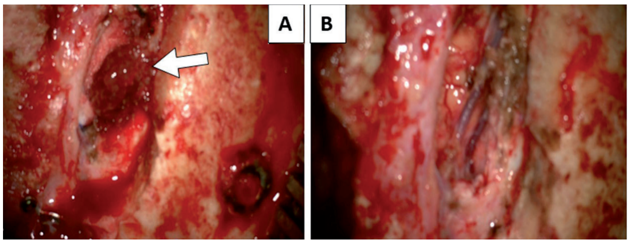

Image 3: A: In this image we can observe the reopening of part of the previous craniotomy. The white arrow indicates the location of the recurring tumor. **B:** Postoperative image. The recurrence has been completely resected. The two cortical veins that were surrounded by the tumor have been respected.

Clinical case

Clinical history

We present the case of a female patient of 65 years of age whose only history of interest was a WHO grade II left frontal parasagittal meningioma, previously operated on two occasions. No adjuvant treatments were administered since it was a complete resection on both occasions. Currently in follow-up in neurosurgery outpatient consultation.

At the last check-up, the patient complained that in recent months she has started to have left hemicranial throbbing headaches which were the same symptoms prior to the last intervention.

In April 2021 a control cerebral MRI was performed *(→ Images 1 and 2).* In it a tumor recurrence is apparent when compared to the prior MRI. The recurrence is located at the left frontal parietal parasagittal level and is approximately 3.5 x 1.5 x 1.5 cm. This mass has infiltrated the bone adjacent to the Superior Longitudinal Sinus, without invading or collapsing it.

Given the radiological findings, it is decided to intervene the patient.

Surgical intervention

The intervention took place under general anesthesia, antibiotic prophylaxis and thromboprophylaxis with pneumatic stockings. The patient is placed in supine decubitus position with the head in a neutral position clamped with a craniostat. Subsequently a neuronavigation recording was performed.

The cutaneous incision was made following the prior scar, exposing all of the marks of the two previous craniotomies. Using navigation, the recurrent tumor is located and a new rectangular craniotomy, smaller than the prior one, is made, just lateral to the Superior Longitudinal Sinus, centered on the tumor. Upon lifting the bone flap, the tumoral lesion is identified which has infiltrated the inner table and the diploe of this flap, so this piece was sent for histopathological for analysis *(→ Image 3).*

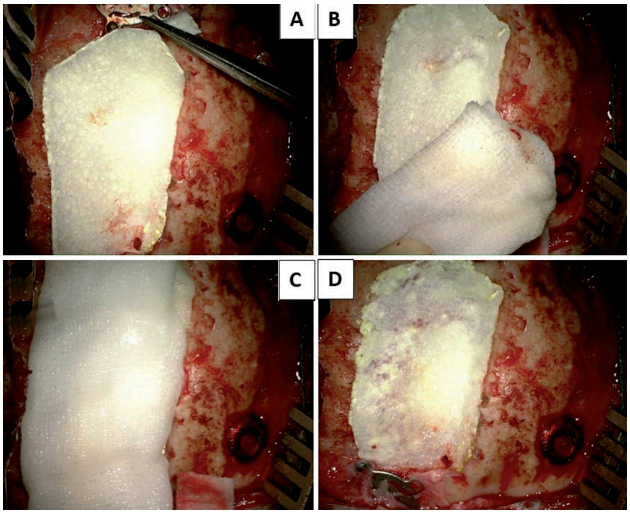

Image 4: In this sequence of images we observe the method utilized for the correct application of TachoSil®. **A:** After putting the edges of the dura mater as close together as possible, we apply the TachoSil® matrix previously moistened with saline solution. The yellow colored active side of the matrix is applied on the surface. For its correct use it is necessary to leave a separation of 1 or 2 cm between the edges of the dura mater and those of the sponge, to do so, since it is a small craniectomy, we cut the TachoSil® matrix to a size that coincides with bone edges. **B and C:** With a humid gauze, slight pressure is applied on the matrix for 3 – 5 minutes. **D:** After carefully removing the humid gauze, the TachoSil® matrix is firmly adhered to the edges of the dura mater and the bone. No CSF leaks are observed.

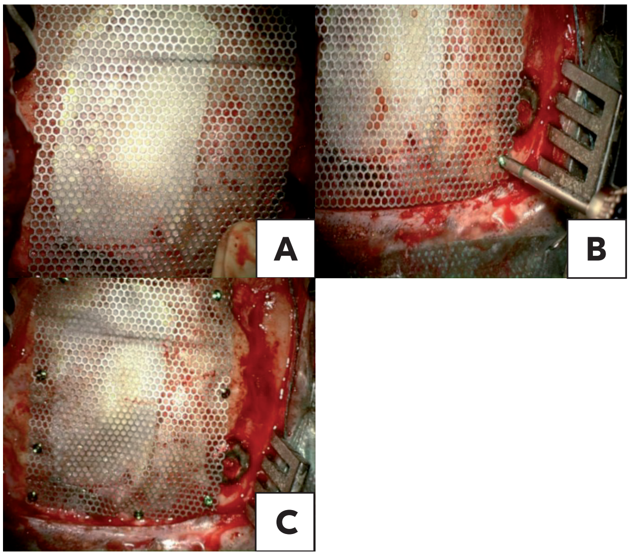

Image 5: A: Having sent the bone piece to the anatomopathological laboratory as it was infiltrated by the tumor, a bone defect remains. Since it is a small defect, it is reconstructed with a metallic mesh. Observe that the TachoSil® matrix completely covers the dura mater at the bottom.
B: The metallic mesh is molded so that it acquires the shape of the skull and is fixed to the cone using screws. **C:** This image shows the result of the final reconstruction. In the background we can observe the TachoSil® matrix that prevents the presence of CSF leaks. The bone defect is repaired with a metallic mesh that is molded so that it adopts the shape of the skull.

Using a surgical microscope, proceed to the dural opening that was made in a circumference around the tumor, without communication with the Superior Longitudinal Sinus. The tumor was resected en block since a good arachnoid plane is maintained with respect to the cerebral parenchyma. Two bridge veins were identified within the tumor that were microdissected and resected *(→ Image 3B)*. Tumor resection Simpson I.

Following this, a careful review of the hemostasis was made since the patient presents slight bleeding in the surgical bed. Hemostasis was performed with bipolar coagulation and TachoSil®. Three small squares were cut and placed on the bleeding spots, so that the hemostatic material stops the bleeding. The yellow colored active side of the matrix was applied on the surface of the bleeding parenchyma and fixed with a humid gauze exercising light pressure of 3 – 5 minutes. Afterwards, for the dural closure, the borders of the dura mater were drawn in. Taking advantage of the hemostatic and sealing properties of TachoSil®, the dural defect was covered with this patch.

To do so, a portion of TachoSil® concordant with dural deft was cut. Using the same technique described above, the TachoSil® adhered easily to the dural surface, preventing epidural bleeding and CSF fistulas *(→ Image 4)*. Finally, the bone defect was covered with a metallic mesh that was molded so that it adhered to the shape of the skull *(→ Image 5)*.
The closure of the skin flap was performed in monoplane, with a non-reabsorbable continuous suture.

Postoperative results

No incidents were registered during the postoperative period. The patient did not develop any focal neuropathy. The wound remained closed and with a good appearance. There were no CSF fistula. The definitive pathological anatomy report was a WHO grade II meningioma. On this occasion, the patient was referred to the Radiotherapy Service for adjuvant treatment as recommended in international neuro-oncology guides.

Discussion

Hemostasis is the physiological process in which the spontaneous form of bleeding is detained as a result of the action of tissue and vascular components, maintaining the integrity of the circulatory system. In the circulatory system anticoagulants predominate, and due to this blood does not coagulate in the stream. But when a vessel or structure of the circulatory system is cut or wounded, the local procoagulants are activated annulling the anticoagulants, and as a result a clot is formed.

To understand how hemostatic agents function, it is vital to first understand how hemostasis functions. This process is divided into two parts for its study, primary and secondary hemostasis.

Primary hemostasis

Is the formation of the platelet plug after a vascular injury. When a vessel is injured, the collagen of the endothelium remains exposed, allowing the platelet activation. In the primary phase of adhesion, the platelets join with the collagen of the endothelium, and perivascular tissue due to the lesion. When the von Willebrand factor (VWF) comes into contact with the collagen it changes its composition, which permits the glycoprotein Ib/IX/V (GPIb/IX/V) platelet membrane to bind to it, attaching the platelet to the collagen. After this union, the phase of activation begins, where the platelet changes its composition, and it converts into a sphere of pseudopods. The substances stored in the granules of the platelets are released into the extracellular space (epinephrine, thrombin, adenosine triphosphate, collagen, thromboxane A2). These substances are platelet agonists that activate the rest of the surrounding platelets, making way for the aggregation phase in which the fibrinogen binds to the glycoprotein IIb/IIIa complexes of adjacent platelets, connecting them into aggregates., forming the primary clot[1,7].

Secondary hemostasis

Consists in the formation of the secondary definitive clot formed by a fibrin mesh. Secondary hemostasis is carried out by plasmatic factors that are activated in a chain reaction. Two routes exist that produce secondary hemostasis: the extrinsic and the intrinsic.

This division is a bit arbitrary and has more to do with the deficiencies of the techniques that at the time were used to unravel the implied mechanisms, than with what really happens in a vascular lesion, since in the latter case various interrelations are established between the routes. Currently the extrinsic route is the most important for the initiation the blood coagulation.

In the extrinsic route, the damaged endothelium (as well as other types of cells such as activated monocytes, macrophages, smooth muscle cells and activated platelets) release Tissue Factor (TF) also known as thromboplastin or factor III. The TF activates factor VII. Following, the TF and factor VIIa activate the factor X in Xa.

In the intrinsic route, also called contact, the process starts with the formation of a primary complex when it contacts the collagen. This complex is formed by kallikrein, quininogene and factor XII with self-catalytic capacity to form factor XIIa, that activates factor XI into XIa and posteriorily this activates factor X into Xa.

Respect to the common part, broadly speaking, implies two steps: in the first place, the facto Xa acts on the prothrombin (factor II) converting it into thrombin (factor IIa). Secondly, the thrombin acts on the fibrinogen (factor I) converting it into fibrin (factor Ia) and on the factor XIII converting it into factor XIIIa. Fibrin polymerizes spontaneously forming bonds. The factor XIIIa stabilizes the clot generating covalent bonds between the fibrin monomers[1,7].

Topical hemostatic agents

Considering the physiological mechanisms of hemostasis, it is possible to create agents that permit the modulation and regularization of these routes. Concretely, during a surgery, products capable of improving hemostasis are needed, to prevent hemorrhages. The topical hemostatic agents available are divided into three groups: passive hemostatic agents, active hemostatic agents and fibrin sealants[8].

- Passive or mechanical hemostatic agents (i.e. gelatin sponges, collagen, ...) interfere with primary hemostasis, helping to form the platelet clots. They create a matrix where the platelets aggregate to form a primary clot.
- Active hemostatic agents (ex. thrombin) intervene in secondary hemostasis, helping to form the clot. They require the presence of fibrinogen to produce fibrin.
- Fibrin sealants (ex. TachoSil®) are thrombin and fibrinogen concentrates. The reaction between the thrombin and the fibrinogen creates fibrin monomers that polymerize creating a clot.

Fibrin sealants and their application in neurosurgery

Given their characteristics, the fibrin sealants are local hemostatic agents of great usefulness in neurosurgery.

As previously said, they contain fibrinogen and thrombin in a dry layer on the surface of a collagen matrix. In contact with physiological fluids, a reaction between the fibrinogen and the thrombin is produced that initiates the last phase of coagulation. The fibrinogen is converted into fibrin monomers, that spontaneously polymerize forming a fibrin clot that keeps the collagen matrix firmly adhered to the tissue. By acting independently from the clotting cascade, they can be used in patients with coagulopathy, fibrinogen deficit and anticoagulation therapies.

This fibrin network along with the support provided by the collagen matrix produces a firm, and mechanically stable structure with good adhesive properties, and therefore at the same time serve as a sealant. This property is of great use in neurosurgery as an adjuvant for dural closure, preventing CSF fistulas and pseudomeningoceles[3,4,5,6].

Although the fibrin sealants (such as TachoSil®) are only authorized as adjuvants for closure of the dura mater, in our experience, we have expanded its use for small dural defects. For example in the case we have previously mentioned. Meningiomas are tumors of dural origin, and therefore, to obtain complete resections (Simpson I or II) it is necessary to cut and close part of the dura mater. In these cases, by making a primary closure, the edges of the dura mater may not be perfectly aligned, minor defects may exist. Even with the use of substitute dural patches, the edges may not align perfectly. In our experience, in addition to the sealant effect, TachoSil® may be used as a substitute for cases of small dural defects. In fact, the fibrin plug is structurally more resistant thanks to the support provided by the collagen matrix. In animal studies, TachoSil® slowly biodegrades leaving little remains after 13 weeks. This is sufficient time for the dura mater to regenerate or a scar to form over the matrix before this degrades, acting as a conducting agent[10].

In the case presented no intraoperative complications occurred. However, due to the parasagittal location adjacent to the Superior Longitudinal Sinus, a complication could have been a tear of this. These are severe complications that are complex to resolve due to the abundant quantity of blood that flows from the sinuses. The fibrin sealants have supposed a major advance and facilitate the resolution of these complications. Their hemostatic and sealing effect are of great use in those cases with substantial loss of blood such as the rupture of dural sinuses. In our experience through the years, we have had a couple of cases in which during a craniotomy a tear occurred in one of the sinuses. In another case it was the existence of a remnant occipital sinus that was torn. On the three occasions we acted in a similar way. In the first place, we rapidly completed the craniotomy. After localizing the bleed in the sinus we applied the TachoSil® matrix.

In the three cases the hemostasis was successful while respecting the integrity of the sinuses and venous return[6].

Cost effectiveness

One of the objectives of neurosurgical intervention is to minimize blood loss and CSF fistulas since these are related to an increase in morbidity and mortality rate, with the consequent increase in costs.

In their article, Rubio-Terrés et. al[9], performed a systematic review of the literature that included 15 studies to identify the clinical studies, or economic analysis, in which TachoSil® is compared to other options such as support treatment during surgery to improve hemostasis, favoring the tissue sealant or as a suture reinforcement in neurosurgery, Urology, Digestive Apparatus Surgery and Vascular Surgery.

Depending on the type of intervention, the time to hemostasis was between one and four minutes, the rate of postoperative complications such as air leaks in pulmonary surgery, intra-abdominal infections, development of lymphocele, pericardial complications, and CSF fistulas, among others were all reduced; in addition to decreasing the hospital stay between one and three days. These effects generated a savings, estimated in total between 98 € and 205 € per patient, according to the study[2,9].

Conclusion

The advance in the development of biotechnology allows us to perform surgical interventions with greater security. Topical hemostatic agents, such as fibrin sealants permit better control of hemostasis. In neurosurgery, they not only permit control of high and low output bleeding, but their sealing effect avoids complications such as CSF fistulas and pseudomeningoceles. The increase of the morbidity and mortality rate and the increase in the number of days of hospitalization of these complications make the use of fibrin sealants such as TachoSil® a cost effective tool.

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8 Experience with epidural hemostasis, repair of the upper longitudinal sinus, and dural reinforcement in a voluminous hypervascularized parasagittal meningioma using TachoSil®

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Introduction

The parasagittal location is relatively frequent in meningiomas, especially in the middle third of the superior sagittal sinus (45 – 70 %). Up to 15 % of parasagittal meningiomas invade the dural sinus and this location is associated with a higher frequency of atypia in the anatomopathological study[2].

The proximity of the superior sagittal sinus and the hyperstosis associated to these tumors leads to a higher risk of bleeding during the performance of the craniotomy and elevation of the bone flap.

The preoperativ image studies are fundamental to determine if a tumor occlusion of the superior sagittal sinus exists and the location of the parasagittal veins in order to plan an efficient and safe surgical strategy.

Clinical case

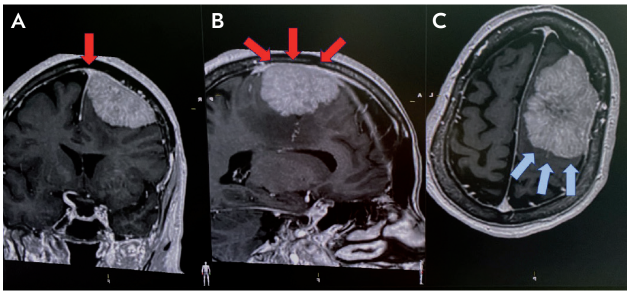

Image 1: Diagnostic cranial MRI. **A:** Coronal, **B:** Sagittal and **C:** Axial slices, showing the right frontal extraaxial, parasagittal expansion process in the motor and premotor areas (blue arrows), affecting the superior longitudinal sinus with a wide extension (red arrows), compatible with the diagnosis of meningioma.

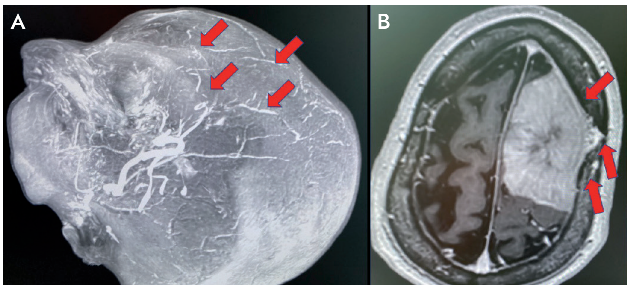

Image 2: A: Cranial Angioma: showing hypervascularization dependent on the middle meningeal arteries. **B:** Axial T1 cranial MRI with Gadolinium: meningeal tumor with broad vascularization on the lateral border.

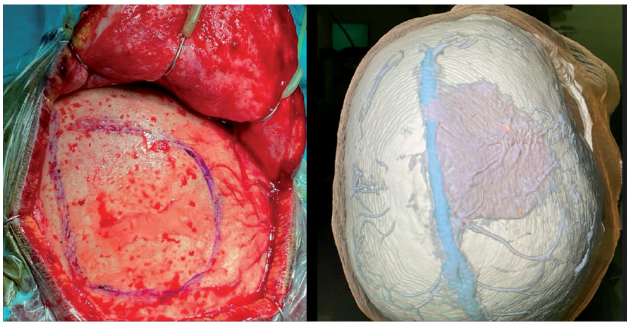

Image 3: Surgical field with markings of the limits of tumor in the skull and comparison with the 3D cranial MRI.

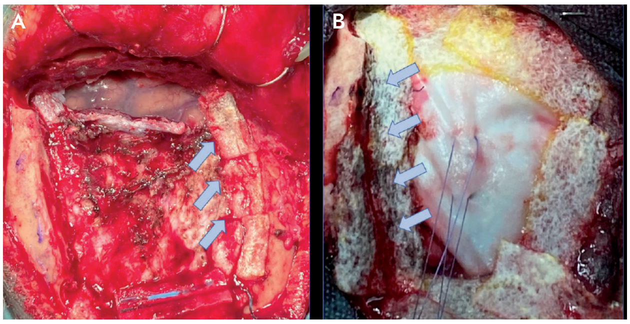

Image 4: A: Lateral epidural bleeding sealed with TachoSil® patches, pending exposure of the inferior and middle margins. **B:** Dura sealed with sutured plasty and TachoSil® patches over the superior sagittal sinus, with signs of bleeding.

Case of a 72 year old patient, who was brought to the emergency room of our center by his relatives due to manic failures, and alteration in behavior of various months of evolution, progressively increasing until the patient was unable to fend for himself. On examination the patient was conscious, partially oriented and collaborative. A discreet bradypsychia was noted without any other new focal point. An urgent cranial computerized tomography (CCT) was performed that showed a voluminous right frontal extraaxial lesion with the effect of a mass, vasogenic edema, and deviation of the midline of 7 mm.

Before these findings of the cranial CT the patient was admitted to complete the study with magnetic resonance imaging (MRI) and surgery. Treatment began with 4 mg intravenous dexamethasone every eight hours.

In the MRI with contrast an extraaxial tumor of 72 x 60 x 30 mm was identified depending on the right frontal convexities, in a precentral location, with a heterogenous sign with intermediate diffusion, and enhancement after the administration of gadolinium, compatible with meningioma *(→ Image 1).*

Presents a mass effect with a midline deviation of 6 mm. At its medial margin it contacted the superior sagittal sinus, which was permeable. In the anterior and posterior margin had contact with two cortical veins, and with another larger one in its cranial margin, probably the Trolard vein. At the lateral level shows hypervasculation both through the bone canals as well as the epidural meningeal *(→ Image 2).*

Once the preoperative study was completed and the consent forms were obtained the procedure to perform the craniotomy and resection of the paracentral lesion guided by neuronavigation and intraoperative sonogram begins *(→ Image 3).* After the parasagittal craniotomy was completed bone and epidural bleeding appears in the lateral limit of the craniotomy, persistent in spite of local hemostasis and dural elevation, deciding to apply TachoSil® patches *(→ Image 4).*

Once the hemostasis was performed the procedure continues to complete the dural opening and microsurgical dissection of the lesion. The same presented a poor plane of differentiation from the underlying cerebral tissue and reached the parasagittal sinus, whose wall was also reinforced with TachoSil® *(→ Image 5).* A complete resection was achieved.

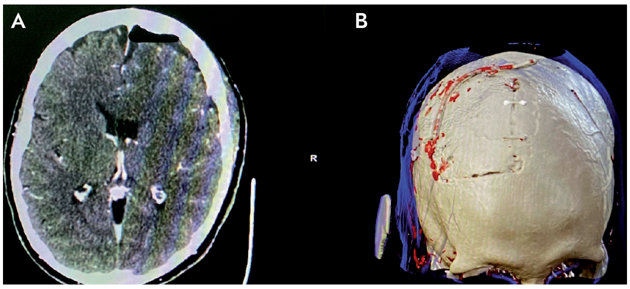

Image 5: A: Postoperative cranial CT without intracranial complications. **B:** 3D CT of reconstructed cranium with reposition of skull bone and subgaleal drainage.

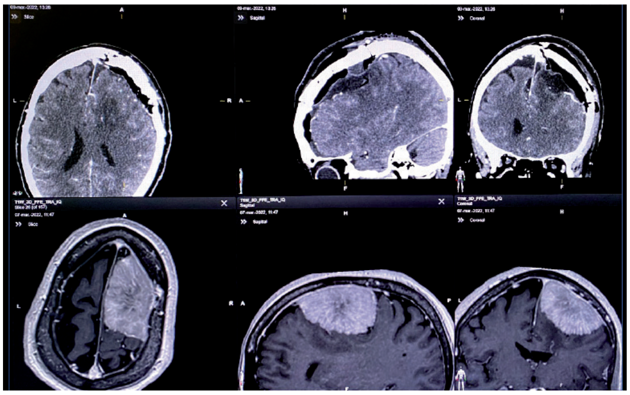

Image 6: Postoperative CT and preoperative cranial MRI in axial, sagittal and coronal slices showing complete resection and absence of intracranial bleeding.

After the resection of the lesion closure through the use of an underlying dural plasty the borders of the plasty are reinforced with TachoSil® to obtain the most hermetic seal possible, minimizing the risk of cerebral spinal fluid fistula. Finally the bone flap was replaced and proceed to closure by planes *(→ Image 6).*

After the surgery the patient presented favorable evolution with progressive clinical improvement. A control CT was made with and without contrast the shows a complete resection without signs of epidural hemorrhage *(→ Image 6).* In the control blood analysis no evidence of anemia was detected. The wound did not show signs of local accumulation. Given the positive evolution the patient was discharged for ambulatory follow-up.

Discussion

The approach to the parasagittal meningiomas is frequently associated with bleeding during the craniotomy and the elevation of the bone flap due to the proximity of the superior sagittal sinus, and the hyperstosis characteristic of these lesions. In this case, after the elevation of the bone flap, we observe abundant bleeding in its entire circumference, especially in the parasagittal and lateral borders, in which the preoperative tests showed global hypervasculation.

Conclusion

As seen in this case, the use of TachoSil® in association with other maneuvers and hemostatics permitted a rapid and efficient control of the bleeding, minimizing the patient's blood loss and reducing the surgical time. In addition, its placement as a patch covering the bone flanges and the dural border permitted control of the epidural bleeding, and prevented blood from entering the surgical field after the dural opening, optimizing the visibility during the surgical phase.

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9 Expansive dural plasty in a patient with severe traumatic spinal cord injury: the importance of the sealing of the dura mater to prevent leaks

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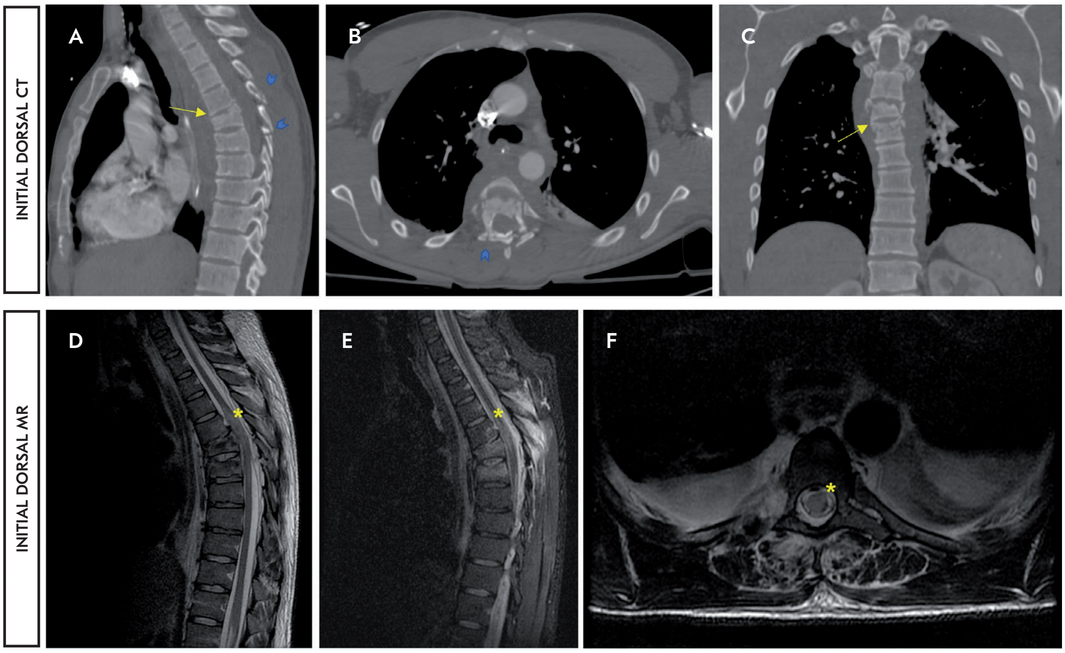

Image 1: Initial image. **A, B and C**: Initial Dorsal CT; a D6 fracture is observed with anterior wedging, post-traumatic loss of height and scoliosis (yellow arrows) as well as extensive affect of posterior elements (blue dots). **D, E and F:** Dorsal MRI: sagittal T2, sagittal STIR and axial T2 sequences, respectively; the hemorrhagic D5 – D6 spinal cord contusion is shown and an extensive edema that ranges from D4 – D7 (yellow asterisks).

Introduction

Acute traumatic spinal cord injury (SCI) refers to a lesion of neuron elements in the spinal cord that produces a temporary or permanent decline at the sensory level, motor and/or bladder/intestinal dysfunction, and it affects 10 – 40 people per million inhabitants in developed countries. In addition to the physical incapacitation, the SCI causes complications that affect the quality of life, including severe mobility limitations (approximately 60 % of the patients with SCI are wheelchair dependent), sociability problems, and psychological and/or medical complications (urinary tract infections, pressure ulcers...)[1].

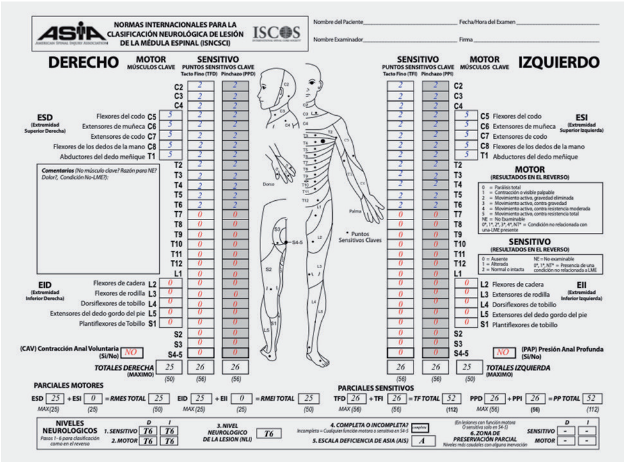

Image 2

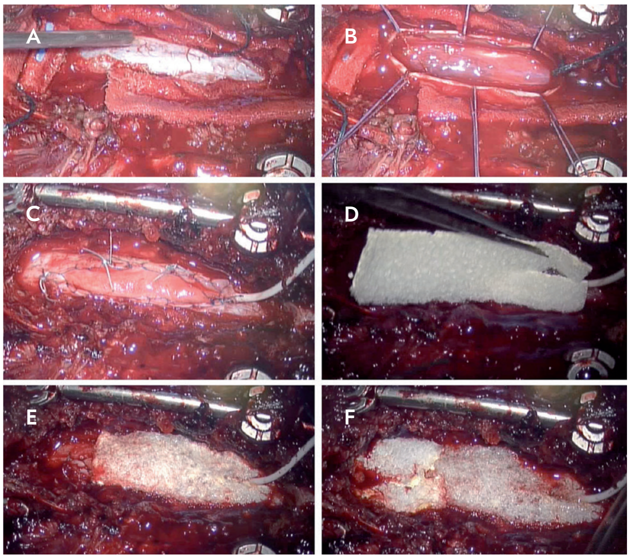

Image 3: Intraoperative images. **A:** Dural sac exposure **B:** Durotomy. **C:** Placement of the intradural catheter and suturable dural plasty. **D, E, and F:** Application of TachoSil® to reinforce the dural plasty.

Other consequences include the economic costs associated with this lesion. It is estimated that the individual cost during the life of only one patient in the United Stats is between one and our million dollars. This elevated cost is in part due to the long life expectancy that the patients that survive the acute phase have[1].

Currently, no medication exists that has been approved for the treatment of acute or chronic traumatic spinal cord injury. It is well established that one of the consequences of SCI is the elevated mortality of neurons and oligodendrocytes in the spinal cord, which affect the motor, sensory and autonomous functions. This cellular mortality occurs in the first days after the accident and is due to the micro environment, that appears in the lesion characterized by the elevated release of inflammatory, oxidant and cytotoxic agents[2]. The use of anti-inflammatories such as methylprednisolone have been proposed for the treatment of SCI. However, the evidence from the studies suggests that the negative side effects of methylprednisolone in patients with SCI are greater than the benefits[3].

The literature supports that an early decompression of the spinal cord improves the evolution in patients with traumatic spinal cord lesions, making the spinal cord pressure reduction one of the factors that most positively influences the evolution of the patient[4]. However, in recent years, different authors have suggested that laminectomy is not sufficiently efficient in the reduction of intraspinal pressure (ISP) because the spinal cord remains compressed by the edematous dural sac, proposing that the durotomy and posterior dural plasty are additional procedures necessary after the laminectomy[5].

In this clinical case we describe a patient with SCI, that was treated by stabilization and fixation surgery, in conjunction with decompression through laminectomy and expansive dural plasty. The hypothesis is that all of these procedures could contribute to a clinical improvement in the situation of the patients with traumatic spinal cord injury without increasing the complications derived from the surgical procedure.

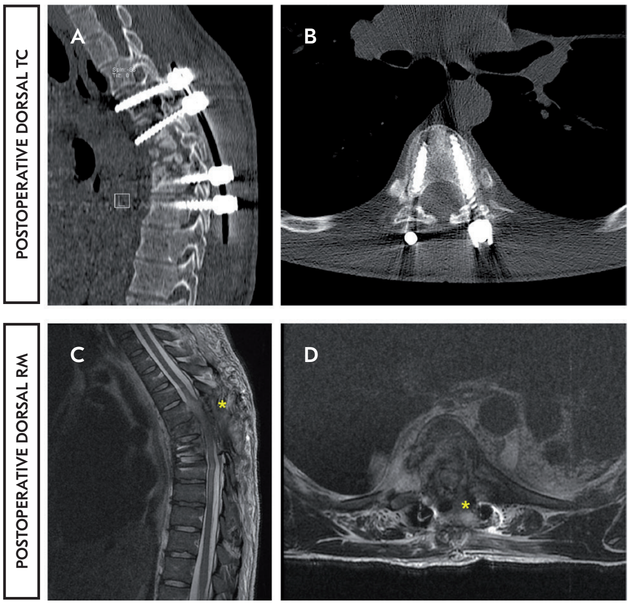

Image 4: Postoperative images. **A and B:** Dorsal CT; Stabilization is observed performed through transpedicular setting of D4 — D5 and D7 — D8.**C and D:** Dorsal MRI: sagittal T2, and axial T2 sequences, respectively; Decompressive laminectomy of D5 — D7 are shown (yellow asterisks).

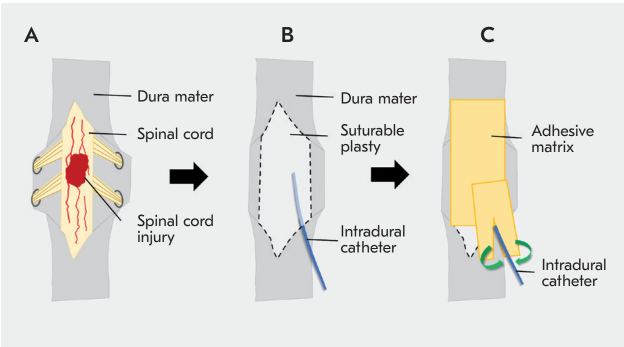

Image 5: Scheme that represents the closure technique used on our patient. **A:** The dural opening is performed using microscopic vision. Once the spinal cord is exposed, we proceed to abundantly flush the spinal cord with saline solution. Broad microsurgical opening of the arachnoids and cleaning and evacuation of subdural hematomas, subarachnoid blood, etc. **B:** Dural closure is performed through an expansive dural plasty, without tension. The dural substitute is suture to the autologous dura mater using 5/0 continuous suture. **C:** The dural plasty if reinforced with a dural sealant (TachoSil®). In our case we use at least two patches of the adhesive matrix previously cut to adapt them to the defect we want to seal, one for the dural plasty, and the other designed to wrap around the monitoring catheter upon exit from the dura mater. After moistening them, the dural sealants are applied and after exercising light pressure of 3 to 5 minutes the sealant is perfectly adhered.

Clinical case

We present the case of a 29 year old male after a motorcycle accident with a high velocity frontal impact. Initially attended by the extrahospital services at the location of the accident, describing an important facial trauma and great deformity at the level of the helmet with a good level of consciousness but without mobility in the inferior members. The vital signs were stable and they proceeded to immobilize with a rigid cervical collar, and transported him in a scoop stretcher by helicopter to our hospital.

Upon arrival he was attended by the Emergency Trauma Intensive Care Unit. In the primary assessment according to the ABCD protocol no outstanding alterations were reported maintaining hemodynamic and respiratory stability with an adequate level of consciousness. In the secondary assessment, the patient presented a wound with bone exposure in the right supraciliary region with crepitation at the periorbital level.

At the dorsal level, pain in spinal apophysis T5 — T7 with articular incongruency, and at the neurological level it is evident that it is impossible to actively move both inferior members in addition to sensitivity at the supraumbilical level. The extraction of an urgent analytical reported no findings of interest except for a discreet elevation of the LDH (370 I/U) and elevation of the CK (368 I/U) in the context of a poly-traumatized patient. Due to the clinical stability of the patient he is transferred to radiology to complete urgent image studies with cranial, cervical and thoracic-abdominal-pelvic CTs. Findings include diverse facial fractures. Fractures at the T5 — T8 dorsal level, the most important at D6 crushing type with anterior wedging, affecting both laminas and retropulsion of the posterior wall *(→ Images 1A, 1B, and 1C).*

With the initial clinical findings the examination was completed with a cervical-dorsal MRI to evaluate the integrity of the spinal cord. The test showed the presence of spinal cord damage at level T4 — T7 in the form of edema with an associated component of hemorrhagic contusion in T5 — T6 *(→ Images 1D, 1E, and 1F).* An epidural hematoma of lamina thickness was observed from T5 — T8 with predominant extension on the left side. We proceed to the performance of a strict neurological exploration, establishing an ASIA A with sensitivity at level T6 *(→ Image 2).*

In the following hours, it was decided to perform emergency intervention by Maxillofacial Surgery to repair the facial wound under the premise that the surgery would control the damage.

72 hours after the accident, the patient was transferred to surgery for spinal cord decompression and stabilization of the fracture with neurophysiological monitoring through somatosensory evoked potentials (SSEP), motor evoked potentials (MEP) and electromyography (EMG).

- In the first step we proceeded to set and stabilize the fracture. To do so, screws guided by navigation were placed at level T4, T5, T7, and T8, and were connected with kyphotic rods.
- In the second step, we proceeded to decompressive surgery by subperiosteal dissection of the paravertebral musculature at level T5 — T7 and posterior laminectomy at the same levels. Visualization of dural integrity *(→ Image 3A)*. We performed a durotomy using a transdural longitudinal approach with CSF output under high pressure *(→ Image 3B)* and posterior placement of a catheter to monitor the intraspinal pressure. Finally an expansive dural plasty was performed employing a suturable plasty *(→ Image 3C)* and using an adhesive matrix as a dural sealant — TachoSil® *(→ Images 3D, 3E, and 3F)*. For its placement it was previously cut in its inferior extreme as "leggings" so that upon placement it would hug the intraspinal catheter favoring not only the dural sealing but also the stability of the intraspinal monitoring.

After the surgery dorsal CT image tests were done that showed adequate placement of the transpedicular fastening material *(→ Images 4A and 4B)*, as well as a dorsal MRI where an adequate decompression from T5 — T7 *(→ Images 4C and 4D)* and absence of complications associated with the procedure are evidenced. Afterwards we proceeded to carry out the definitive surgery of setting the facial fractures by the Maxillofacial Surgery team. During the following days the intraspinal pressure remained in physiological range and there were no data of CSF fistula at any time during the evolution. Twelve days after admitting the patient, in a clinically stable situation, without changes upon neurological examination (ASIA A, neurological level T6), and without other incidents, the patient is transferred to the National Paraplegic Hospital of Toledo to continue recovery and start rehabilitation.

Discussion

Currently, no medication exists that has been proven effective for the treatment of acute or chronic traumatic spinal cord injury. Currently anti-inflammatory treatments such as methylprednisolone are available, although clinical studies have indicated that this treatment strategy does not provide solid benefits for SCI to support this treatment as standard[3].

The patients with spinal cord injuries are routinely submitted to setting and stabilization surgery. In addition, in the case of radiological findings that manifest as spinal cord compression, neural tissue decompression was also performed. In our service both objectives are carried out in one surgical procedure, in order to minimize the risks associated with a second intervention.

The literature supports that an early decompression of the spinal cord improves the evolution in patients with traumatic spinal cord lesions, making the spinal cord pressure reduction one of the factors that most positively influences the evolution of the patient[4]. To perform the decompression of the spinal cord, the laminectomy is a procedure whose validity is beyond all doubt.

In contrast, the durotomy is not a standardized process in habitual clinical process, although there is increasing evidence about its security and potential benefit of the patient's evolution.

For example, Phang, et al. 2015[6], compared the exclusive laminectomy treatment to the laminectomy combined with dural plasty and they concluded that the patients with traumatic spinal cord injuries in which a laminectomy and dural plasty were performed, the dural compression was eliminated by reducing the SCI improving the spinal cord perfusion pressure (SCPP). These changes could reduce the secondary ischemic damage described in patients with spinal cord injuries[7].

In this same direction, Werndle et al. 2014[5] suggest that laminectomy is not sufficiently efficient in the reduction of SCI because the spinal cord remains compressed by the edematous dural sac, proposing that the durotomy and posterior dural plasty are necessary additional procedures after the laminectomy.

SEX	AGE	WOUND TYPE	ASIA	PATHOLOGY	SURGERY	INFECTION	CSF FISTULA
Male	44	Fall	A, Level T6	Fx T7 + HSCC	FTP T5, 6, 8 and 9 + Lami. T5 – T9	NO	NO
Male	29	Motorcycle accident	A, Level T6	Fx T6 + HSCC	FTP T4, 5, 7 and 8 + Lami. T5 – T7	NO	NO
Male	56	Motorcycle accident	A, Level T5	Fx T6 and T7 + HSCC	FTP T4, 5, 7, 8, 9 + Lami. T5 – T7	NO	NO
Male	52	Bicycle accident	A, Level T4	Fx T4 – T5 + HSCC	FTP T2, 3, 4, 6 and 7 + Lami. T3 – T6	NO	NO
Male	32	Motorcycle accident	A, Level T4	Fx T4 + HSCC + HDD	FTP T2, 3, 5, 6 + Lami. T3 – T5	NO	NO
Male	46	Fall	A, Level T11	Fx T12 + HSCC	FTP T11, 12, L1, 2 + Lami. D11 – L1	NO	NO
Male	57	Fall	A, Level T3	Fx T3 and T4 + HSCC	FTP T1, 2 and T5, 6 + Lami. T3 – T5	NO	NO
Female	63	Car accident	A, Level T10	Fracture T11 + HSCC	FTP T8, 9, 10, 11, 12, L1 + Lami. T10 – T12	NO	NO

Table 1: Cases with acute spinal cord injury treated with expansive dural plasty.
Fx: Fracture, **Lami:** Laminectomy, **HSCC:** Hemorrhagic spinal cord contusion, **CSF:** Cerebrospinal fluid.

In consequence, our protocol includes the setting, decompression with dural plasty and placement of a catheter to monitor the intramedullary pressure in the same surgical intervention, by which we minimize the risk and ethical consideration associated to a second intervention, as well as minimize the impact of any possible adverse occurrence on the condition of the patients. Unfortunately, decompression with dural plasty is not exempt from complications, among them worth naming a high risk of cerebrospinal fluid fistula (CSF), leading in addition to need for placement of CSF drainage and/or revision surgery, complications associated with the wound and/or infections. To minimize the possibility of appearance of CSF fistula the selection of the closure technique was of extreme importance In our case we used a continuous suture with 5/0 stiches to suture the dural flap. At the same time, based on our experience, it is of vital importance to reinforce the dural plasty with a dural sealant of the TachoSil®. As observed in the scheme *(→ Image 5)*, after cleaning and drying the area, the adhesive matrix was moistened with a saline solution and applied. In our case we used at least two patches previously adapted to the defect we want to seal, one for the dural plasty, and the other designed to wrap around the monitoring catheter upon exit from the dura mater. After exercising light pressure for 3 to 5 minutes the sealant is perfectly adhered, and with the Valsalva maneuver we can verify if CSF output is produced or not. With the technique described for the sealing of the dura mater, in our series of spinal cord injuries treated by expansive dural plasty, we did not observe any postoperative CSF leaks *(→ Table 1)*.

Conclusion

We conclude that the decompression with dural plasty is a procedure, that is increasingly used in patients with ASCI, in those which the use of an adhesive matrix like TachoSil® can significantly reduce the appearance of CSF fistula, also preventing complications derived from CSF leakage.

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10 Use of a medicated matrix both as a hemostatic and a sealant in retro-sigmoid craniotomy for excision of diffuse large B-cell lymphoma at the right cerebellar pontine angle

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Introduction

TachoSil® is one of the fundamental materials habitual in neurosurgery practice.
Its is comprised of an adhesive collagen matrix covered on its yellow side with fibrinogen and human thrombin[1]. We present a case of a diffuse large B-cell lymphoma of the CNS located in right pontocerebellar angle of rapid growth.

The case is of high interest due to its infrequent location[2] and scarce lymphoma patients in habitual practice[3,4], but with great importance considering its diagnostic possibility and therapeutic management[4,5]. In addition, the use of TachoSil® in this case is of particular usefulness since the tumors in the pontocerebellar angle have the peculiarity of presenting a difficult hemostasis since they expose a large quantity of veins during the approach, and they tend to be tumors adhered to the dura mater[6,7].

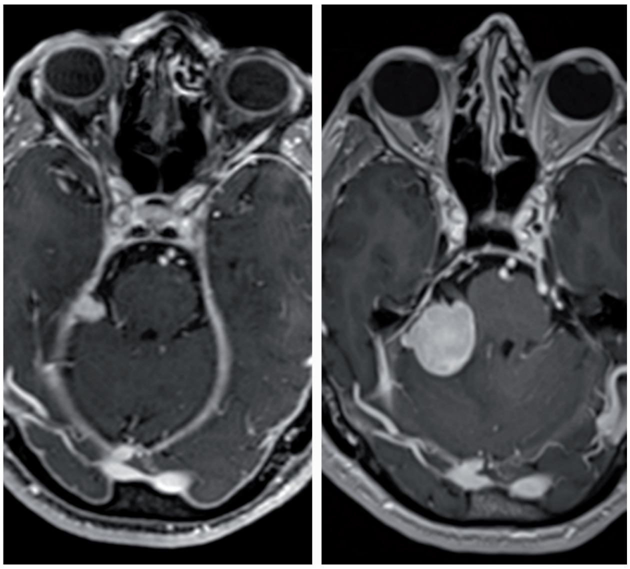

Image 1: Evolution of a lesion in cerebral magnetic resonance imaging with less than three months between them.

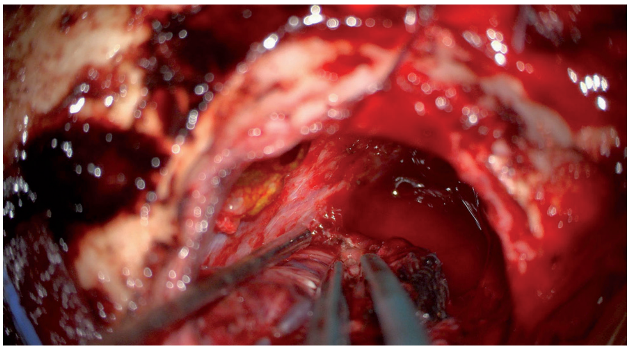

Image 2: Hemostasis with TachoSil® of Dandy's petrosal vein.

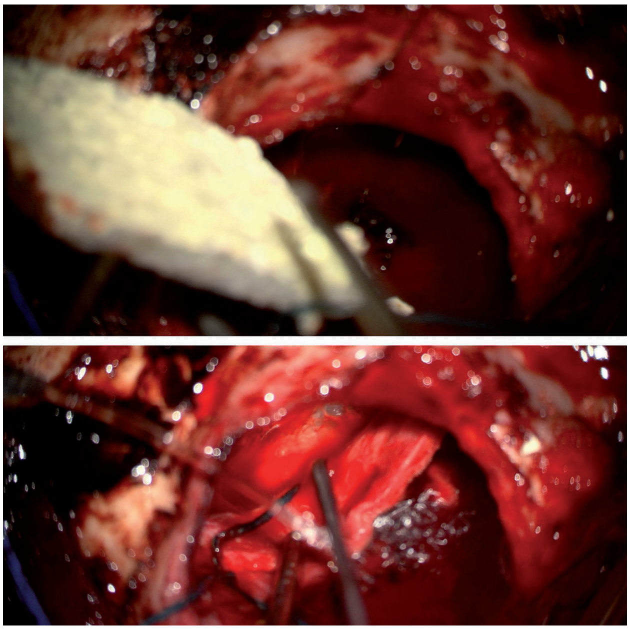

Image 3: Hemostasis sequence with TachoSil® moistened with physiological solution to increase the adhesion in the entrance to the superior petrosal sinus.

Clinical case

Case of a 60 year old patient afflicted with a progressive loss of hearing, right facial paralysis, and instability when walking. The patient had an extra-axial tumor in the right pontocerebellar angle with the base apparently implanted fundamentally in the tentorio with a growth of more than 2 cm in MRI less than three months.

Due to the rapid clinical evolution and the tumor we recommended surgical treatment to confirm the pathological anatomy that was performed intraoperatively suspecting meningioma, schwannoma, or ependymoma as differential diagnoses. A resection was performed of a reddish vascularized tumor in the pontocerebellar angle of apparent flocculus origin, through a retrosigmoid craniotomy. A complete resection of the tumor was achieved conserving the VII-VIII package, maintaining pairs IX-X-XI in their cistern and V, IV all integral. Upon finalizing the surgery a tear occurs and ruptures the Dandy vein that produced profuse bleeding due to traction when the cerebellum is detached. Careful hemostasis was performed of the same with a bipolar clamp, hemostatic based on reticulated gelatin granules and human thrombin, absorbable hemostatic of oxidated cellulose and TachoSil®.

The entrance to the superior petrosal sinus must also be plugged with TachoSil®. Closure was carried out through dural plasty with an absorbable collagen implant, TachoSil® and hydrogel (a solution based on polyethylene glycol ester and trilysine amine) sealing, with posterior reposition of the bone flap. Neurophysiologic navigation monitoring was used during the procedure, and intraoperative pathologic anatomy suggested an ependymoma.

In spite of presenting a certain improvement, the patient subsequently sustained a right cerebellar hemispheric infarction postoperatively that required reintervention through a right suboccipital craniectomy. Afterwards the histological diagnosis was a large B-cell lymphoma, of aggressive behavior and high degree of malignancy.

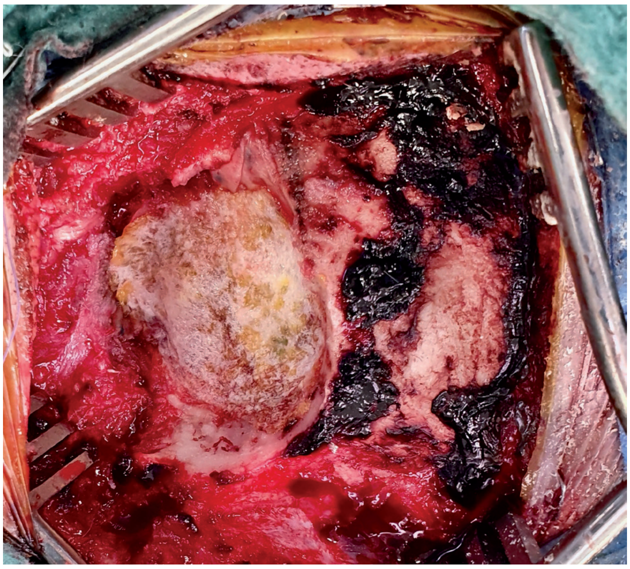

Image 4: Closure using dural plasty with absorbable collagen implant and TachoSil® prior to replacement of the bone flap in right retrosigmoid craniotomy.

Discussion

We highlighted the use of TachoSil® during the surgery is fundamental both as a hemostatic for the remission of the venous bleeding, sinus veins and tumor vessels proceeding from the dura mater as well as a sealant during the dural closure prior to the placement of the bone flap.

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11

Idiopathic dorsal spinal cord herniation: echo-guided micro-surgical sealing with suturable and biocompatible dural plasty

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Introduction

Idiopathic dorsal spinal cord herniation (IDH), through an anterior dural defect, is a rare entity. It was described by Wortzman, et al. for the first time in 1974, and until now, less than 150 cases have been described in the literature[1,2]. The idiopathic character of the IDH distinguishes it from traumatic, iatrogenic and inflammatory origin and, although some authors have postulated a congenital defect of one or both dural layers, acquired or including even a dural fissure originating at the root of a calcified dorsal hernial disc, the physiopathological mechanism of the IDH is unknown with certainty at this time.

IDH transpires as a progressive clinical case of slow evolution consistent with dorsal pain up to the myelopathy with sensitive motor disorders and intestinal and sphincter regulation according to the degree and level of affectation. The diagnosis of this pathology tends to be late due to the scarce frequency of the case and in many cases is confused with a compressive dorsal arachnoid cyst. Magnetic resonance imaging (MRI) is the preferred diagnostic modality in such cases since it permits detection of the dural defect and the spinal cord herniation as long as this diagnosis is suspected[3,4].

Surgery is the treatment of choice using a posterolateral costotransverse approach to the region affected by the IDH. The surgical technique for the repair varies from the sealing of the anterior dural defect with sutures or the use of biocompatible dural plasty to achieve amplification of the defect to prevent spinal cord compression. The majority of authors use dural plasties for repair with good functional and radiological results in the medium and long term[5,6].

Today, in neurosurgical procedures, the use of intraoperative imaging in neurosurgical procedures has become more and more disruptive. Among these techniques, the intraoperative ultrasound (IOUS) is one which has experienced the most evolution both in the quality of the image as well as the smaller size of the exploration catheters. This has permitted their use in cranial and spinal cord surgeries, being one of the few intraoperative imaging techniques capable of providing a quick image in real time[7]. In treatment for IDH to date the use of IOUS has not been described as a proven "in situ" technique of the correct sealing of the dural defect. Below, we will present a clinical case of a patient with IDH, who after being diagnosed, underwent hernia restauration surgery and echoguided sealing of the ventral dural defect using an acellular collagen matrix plasty of bovine origin.

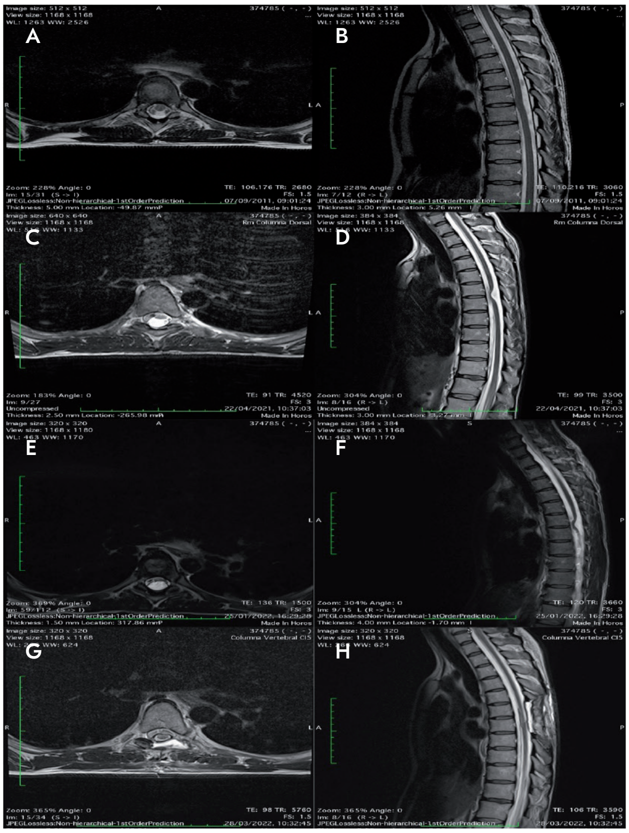

Image 1: Radiological follow-up dorsal magnetic resonance imaging T2-weighted sequence in axial and sagittal planes. **A and B:** Initial resonance; **C and D:** Initial resonance of myelopathic symptoms; **E and F:** Presurgical resonance; **G and H:** Postoperative control resonance.

Clinical case

We present the case of a 46 year old female, without other pathological history of interest that debuted eleven years ago with self-limiting back pain of months of evolution and without other accompanying symptoms or clinical signs. The first magnetic resonance image showed at T6 — T7 a lesion with a probable non-compressive posterior dorsal arachnoid cyst *(→ Images 1A and 1B).* Annual clinical and radiological follow-up is determined.

After 10 years of stable follow-up, the patient presented the beginning of progressive neurological symptomology of instability when walking secondary to palsy 4/5 and paresis in the left inferior extremity, contralateral thermoalgesic sensory level T8 and progressive episodes of urgent need to urinate and urinary incontinence. In the control resonance an increase in the posterior liquor cavity to the dorsal spinal cord with doubtful image of defect of the ventral dura mater *(→ Images 1C and 1D).*

In the differential diagnosis with the initial arachnoid cyst, the possibility of IDH was evaluated. It was determined that a new Tesla 3 resonance be carried out in which the diagnosis of IDH T6—T7 is confirmed through the left ventral defect dorsal dura mater at the same level *(→ Images 1E and 1F).*

Due to the progressive clinical evolution, it was recommended to perform open repair surgery with neuro monitoring and intraoperative imaging (Ultrasound). The patient underwent a laminectomy with partial T6 — T7 arthrotomy to repair the defect and the hernia. After exposing the dorsal face of the dura mater an intraoperative ultrasound was used (BK5000, N11C5s (9063) Burr Hole Transducer, BKMedical Inc.) to locate and optimize the pathological region and the anterior dural defect (→ *Images 2A and 2B).*

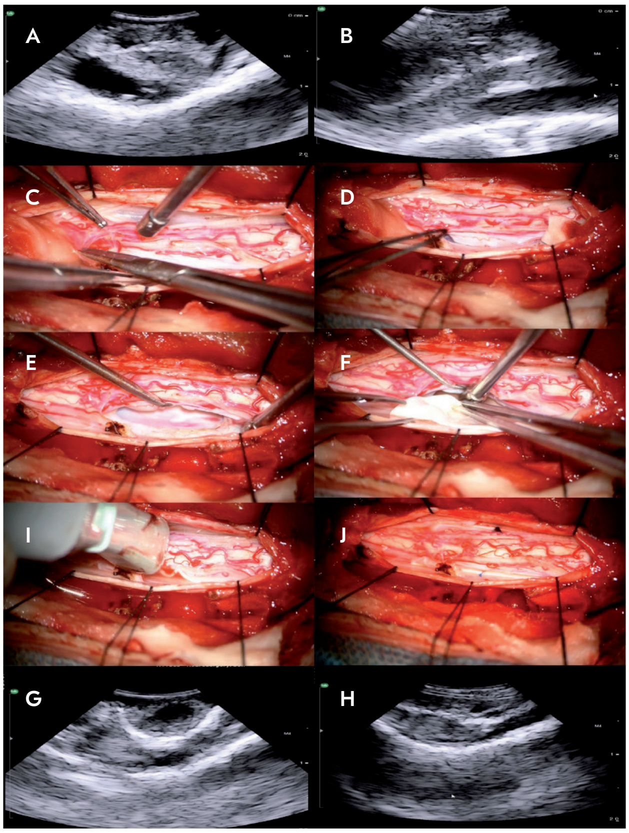

Image 2: Surgical procedure. **A and B:** Axial and sagittal ultrasound examination prior to durotomy where the spinal hernia can be seen through the dural defect; **C:** Arachnoid dissection and dentate ligaments section. **D and E:** Spinal extraction and exploration of ventral defect; **F:** Placement of the acellular collagen matrix designed based on the ultrasound image; **G:** Ultrasound verification of the correct placement of the sealant matrix; **H:** End of sealing and setting with bilateral suture of the dural plasty; **I and J:** Axial and sagittal ultrasound examination after the repair of the defect, where the correct placement of the sealant and the absence of complication can be appreciated.

After examination we proceeded to the intradural exploration with durotomy by the posterior middle line. After arachnoid dissection and exposition of the spinal cord, the hernia could be seen through the ventral defect of the dura mater. The dentate ligaments were sectioned bilaterally and the spinal cord was mobilized to extract it through the ventral dural orifice *(→ Images 2C and 2D)*. Once the dural defect was exposed it was sealed using an acellular collagen bovine plasty fixed bilaterally by 5/0 monofilament suture *(→ Images 2F – 2H)*.Through the ultrasound image the correct sealing of the defect, the normal position of the spinal cord and the absence of complications before and after the dural closure were verified *(→ Images 2I and 2J)*. The surgery was concluded with the closure of the different layers of the cutaneous-muscle wound. The intraoperative neuromonitoring did not register incidences during the surgery.

After surgery the patient remained in bed 24 hours to improve the liquoral hermeticity of the wound. Progressive wandering started after this initial period and discharge was at 72 hours after the procedure, once postoperative complications were ruled out through postsurgical resonance control, that confirmed the sealing of the defect and the restauration of the size of the spinal canal, as well as the position of the spinal cord being practically normal *(→ Images 1G and 1H)*.

At three months of follow-up the patient had experienced a clinical improvement with the resolution of the palsy, hypoesthesia and the paresthesia in the left inferior extremity. He had no episodes of incontinence and less frequent urinal urgency. The control resonance confirmed the resolution of the spinal hernia with correct position of the dural plasty used during surgery. After these controls moving forward semester/annual controls will be performed in function of the evolution.

Discussion

In this clinical case, a case of IDH is presented that aligns with that described in the literature, the diagnostic difficulty, the progressive clinical case, and the need to repair the ventral dural defect through surgery, but includes the use of intraoperative ultrasound as a precision and safety tool in the surgical treatment of this entity.

In the majority of published IDH cases the delay in the diagnosis is described due to a very low incidence of this pathology, and the common confusion with the presence of an arachnoid dorsal cyst[8]. This late diagnosis explains the appearance of potentially serious symptoms of spinal incarceration and conditions the need for repair treatment in this phase. In fact, extreme cases have been published in which the spinal hernia has been produced in an atypical way at the intravertebral level. In our case the clinical evolution and radiology permit us to confirm the silence of the clinical case and the need for surgical treatment in its final phase. Due to scarce experience no evidence exists with respect to the suitability of early treatment, even in the asymptomatic phase, of IDH.

The need for surgical repair of the ventral dural defect is common in the cases described in the literature. The most common surgical strategies range from the closure of the dural defect through suturing, the amplification of the defect to prevent dural incarceration and the placement of a dural patch, a bit larger than the defect, that permits the sealing and prevents the reherniation[6].

This last technique is the most frequently used and was the one performed in our case. The use of a suturable acellular collagen bovine matrix permits coverage of the entire dural defect requiring bilateral suturing to prevent displacement of the implant. Although it is not discussed in the literature, this “inlay” repair technique permits the most effective sealing of the defect, not only because it entirely covers the dural opening and the herniation, but also because just as it is described for other indications, the pressure of the internal content of the dural sac (CSF and its own spinal cord) facilitated the continuous closure of the repaired defect[9].

In addition this avoids the use of adjuvant sealing substances (fibrin glue, etc...) that could generate an intolerable mass effect or undesirable reactions on the spinal cord.

Finally, we consider that the IOUS during the repair procedure of IDH is a technique that should be considered as an excellent surgical adjuvant at the time of confirming the correct repair of the defect and the absence of surgical complication in this surgery. With increasing use starting in the 80s, the use of ultrasound in spinal procedures had not experienced the growth projected until recent years. Improved technology, with better quality imaging and smaller ultrasound catheters, along with the possibility of neuronavigation have permitted that this technology is increasingly consolidated in the surgical arsenal to help the spinal surgeon.

Ultrasound permits an intraoperative image in real time, quickly and precisely, and with the capacity to explore soft tissue in an effective way. It does not imply radiation for the patient nor the surgical team and, in addition its cost is economical, far below other intraoperative technologies such as for example computerized tomography or resonance. Concretely, in spinal surgery, multiple indications have been describe where IOUS can be useful. The most frequent is intraspinal tumor pathology where IOUS permits the localization of the tumor and the evaluation of the degree of resection.

Of interest in our case is the publication of the use of IOUS in spinal surgery for the control of ventral pathology of the spinal cord. Concretely its use has been reported in surgeries in the region of the ventral dural sac, discectomies in the thoracic region, confirmation of the efficacy of an exclusive posterior decompression in patients with a narrow canal for mixed antero-posterior compression and even to verify the spinal canal in the reduction and absence of bone fragments of anterior burst fractures in the dorsal lumbar region[10].

This utility, applied to the case described, has permitted, in our experience, the confirmation of the IDH diagnosis and the sufficiency of the surgical approach for its repair (need to amplify laminectomy) before performing the dural opening, determine the extension of the dural defect prior to moving the herniated spinal cord, taking measurements in real time to obtain the optimum size of the sealant patch, confirming the correct placement of the patch reducing manipulation of the spine, verifying, during the closure in layers, the correct caliber of the dural sac and the absence of intraoperative complications during the final closure.

Conclusion

In conclusion, we consider that IDH is a surgical entity that benefits from surgical repair using a dural matrix sealant in an effective way. In this procedure, we recommend the use of IOUS to achieve greater security and optimize the results.

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12 Left middle ear cholesteatoma with rupture of the tympanic membrane and invasion of the middle fossa. TachoSil® as a sealant and hemostat to control severe bleeding. Case Review

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Introduction

Cholesteatomas are lesions formed by stratified squamous epithelium that affect the middle ear. They are histologically benign lesions but have an invasive component, eroding the temporal petrous bone during its growth with possible effects on the neurovascular structures. This way they can produce a dehiscence of the tympanic membrane provoking a meningocele or encephalocele with risk of CSF fistula. The treatment consists of surgical excision of the lesion, on occasions requiring review of the middle fossa to close the bone defect.

At the time of considering a surgery over the temporal lobe and middle fossa the possible anatomic variants of the inferior anastomotic vein or the Labbe must be considered to be able to preserve it to the degree possible. The Labbe vein forms part of this venous system and connects the veins the length of the Silvio fissure with the transverse sinus. It tends to be located at the medial level of the temporal lobe with a posteroinferior trajectory but can cross as far back as the posterior limit of the lobe[1].

Its injury can lead to an infarction of the temporal lobe with the most frequently described symptoms being headache and seizures. When a dominant Labbe vein is affected it can also provoke aphasia, dysarthria, motor focality and memory impairment[2].

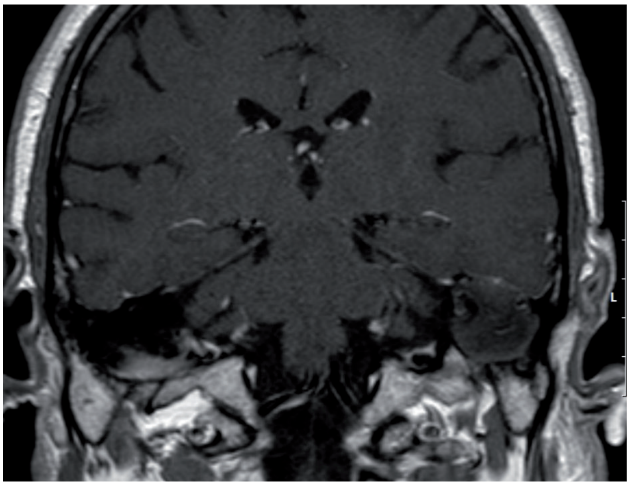

Image 1: Coronal plane of magnetic resonance imaging, T1 sequence contrast, lesion in middle ear with bone erosion suggestive of Cholesteatoma.

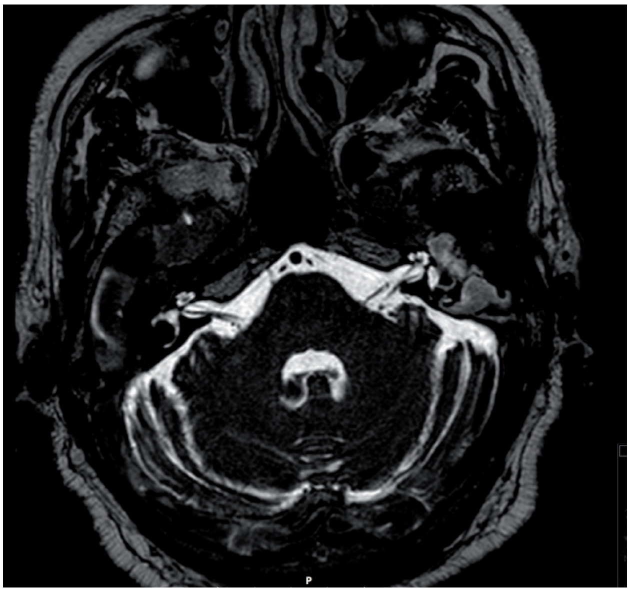

Image 2: Axial plane of magnetic resonance imaging, T2 sequence, lesion in left middle and external ear with suggestive of Cholesteatoma.

Clinical case

We present the case of a male of 60 years of age, without medical-surgical history of interest, who consulted in otorhinolaryngology for left sensorineural hearing loss. In addition to otoscopy and audiometry the study is completed with computerized tomography (CT) imaging and magnetic resonance imaging (MRI) of petrous bones. On CT a lesion can be seen that occupies all of the mastoids and middle ear with erosion and remodeling of the bone at the scutum, tympanic membrane and temporal fossa levels. In the cerebral MRI the lesion is confirmed suggesting cholesteatoma of the left middle and external ear associating image that suggests encephalocele in left petrous bone *(→ Images 1 and 2).*

With the diagnosis of chronic cholesteatomatous otitis media of the left ear it is decided to program surgery for excision and sealing of the middle fossa with a temporal muscle flap in the first place followed by a subtotal petrosectomy and labyrinthectomy to excise the cholesteatoma. Collaborative surgery among the neurosurgery and otorhinolaryngology services.

A left temporal craniotomy was performed. Through a subtemporal exploratory approach the cholesteatoma could be seen on the floor of the middle fossa associated with rupture of the tympanic membrane but with preserved dura mater. As an incidence during the exploration a profuse venous bleed was produced secondary to the rupture of the left inferior anastomotic vein in the union of the same with the transversal sinus that was controlled after the placement of TachoSil® over the point of entrance of the Labbe vein *(→ Image 3).*

As the excise of the cholesteatoma continues, after exploration of the hypotympanum and directing the approach toward the posterior fossa, a dural defect that connected the middle fossa and the posterior fossa could be seen *(→ Image 4).*

Since it was impossible to put a suture stitch for the closure decision for sealing with TachoSil®.
Also, due to the absence of bone with gulf exposure in hypotympanum it was also covered with TachoSil® *(→ Image 5).*

After the surgery the patient did not present hemorrhagic complication in the control cerebral CT and did not present direct or indirect signs of CSF fistula.

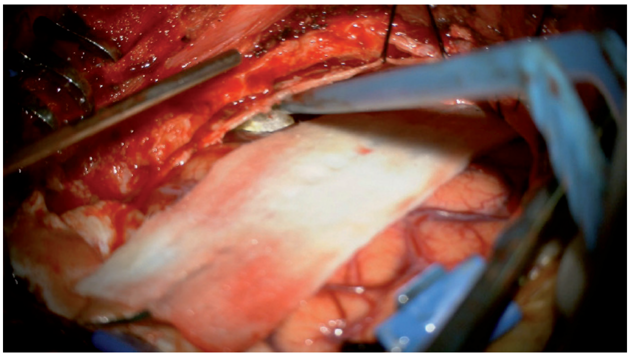

Image 3: Intracranial view: Intraoperative view, left temporal lobe and middle fossa floor, placement of TachoSil® over the confluence of the inferior anastomotic vein and the transverse sinus.

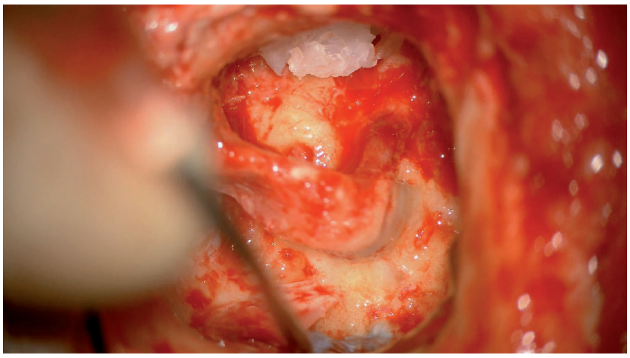

Image 4: Extracranial view: Bone defect with dural exposition of the posterior fossa. Aspirator over dura mater.

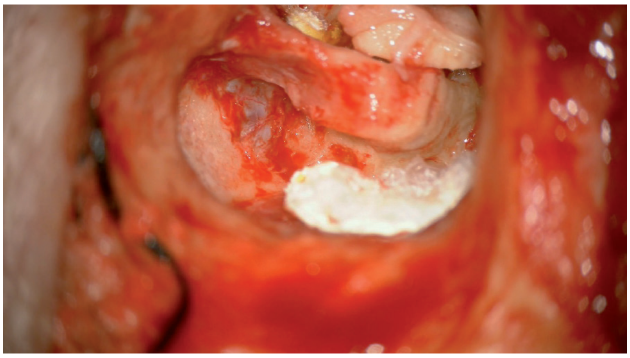

Image 5: Extracranial view: TachoSil® over the bone defect to seal it.

Discussion

During neurosurgical interventions we can encounter different adversities such as bleeding, dural defects with associated CSF fistula or nervous structures lacking their coverage due to the effects of the tumor. These complications can not always be controlled by bipolar coagulation, closure with sutures or interposition of autologous tissue. As an alternative the use of collagen, hydrogel or fibrin sealants are more and more frequent. TachoSil® is a hemostat with a collagen matrix with thrombin and fibrinogen, that has demonstrated to be a good alternative as a sealant on dural defects at the base of the skull[3] and in severe bleeding as strong as an exposed dural sinus in this case.

Conclusion

Here we present a case in which we have made use of the diverse advantages offered by TachoSil®, control of intraoperative bleeding and closure of dural defect, with good postsurgical results and without development of complications.

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13 Horsetail neuroendocrine tumor. Clinical case and literature review

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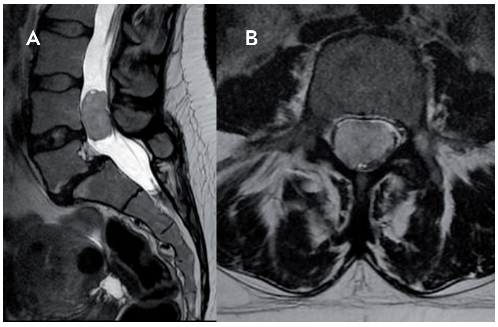

Image 1: Magnetic resonance imaging with contrast, T2 where a nodular lesion is seen at the level L4 of the body dependent on horsetail roots, that totally occupies the spinal canal and displaces and compresses the periphery nerve roots. **A:** Sagittal slice. **B:** Axial slice.

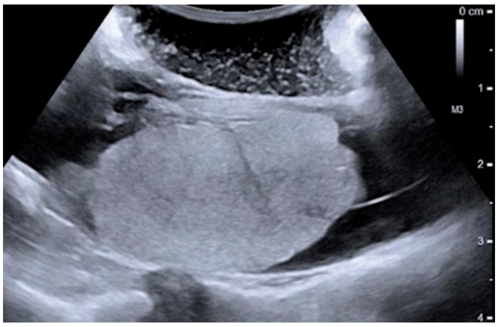

Image 2: Intraoperative ultrasound confirmation. A hyper-echoic intradural nodular lesion is seen measuring 3.8 x 2.5 cm that corresponds with the magnetic resonance image.

Introduction

Horsetail neuroendocrine tumors (previously called paraganglionic) are extremely rare with approximately 250 cases described in the literature, are derived from paraganglionic neuroepithelial cells habitually in the gastrointestinal or respiratory tract, although they are even less commonly described in other tissues such as the urethra, liver, larynx or central nervous system. Due to the few cases described it is habitually erroneously diagnoses as neurinomas or myxopapillary ependymomas, which can lead to an inadequate management or prognosis.

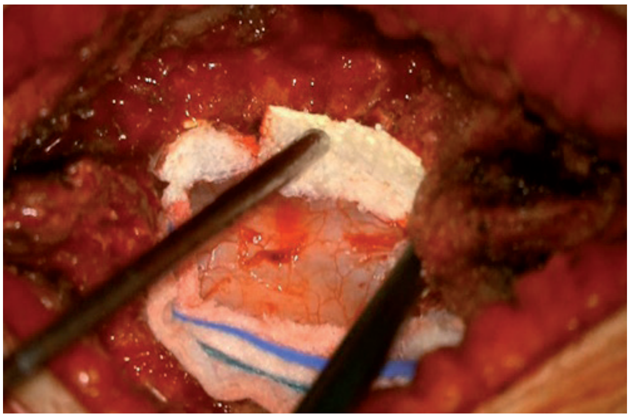

Image 3: Sealing of the epidural space with TachoSil® to prevent epidural bleeding after the decompression derived from the dural opening and output of CSF.

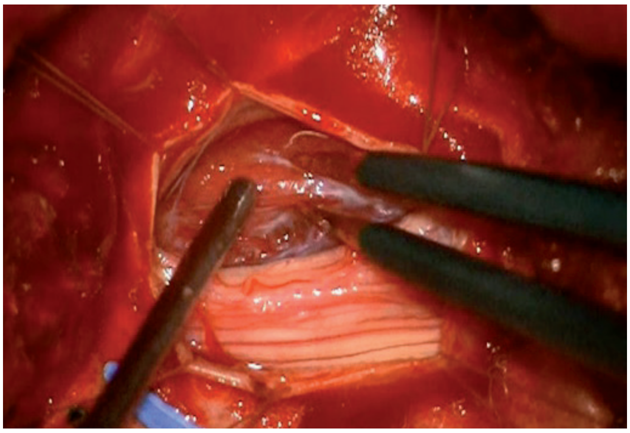

Image 4: After the durotomy and mobilization of the horsetail roots the dural sac with a reddish highly vascularized and friable tumor which was difficult to mobilize.

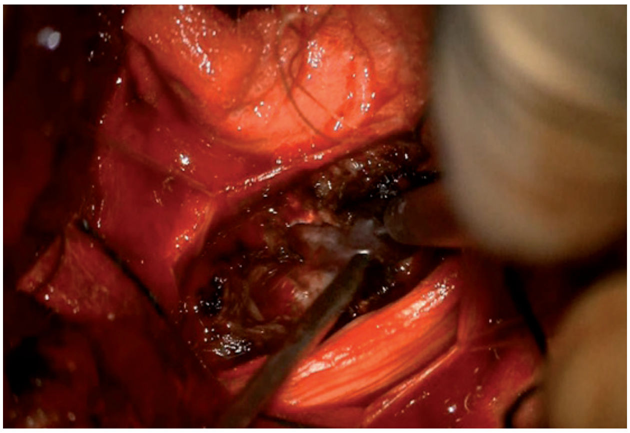

Image 5: Debulking of the lesion with ultrasonic aspirator to allow mobilization of the lesion and identification of the cranial and caudal margin.

Clinical case

Female of 35 years old, without medical history, came a case of emergency on multiple occasions due to high intensity lumbar pain that irradiated toward both gluteus, which did not improve with conventional analgesics. No motor or sensory deficits.

A lumbar MRI was requested *(→ Images 1A and 1B)* where an intradural tumor could be seen that completely occupied the spinal canal of the body of L4 with displacement and compression of the roots of the horsetail, suggestive of neurinoma, meningioma or less likely myxopapillary ependymoma.

Surgical treatment using a posterior approach on the middle line centered on L4 was decided, intraoperative ultrasound confirmation *(→ Image 2)*, posterior sealing of the epidural space *(→ Image 3)* with a collagen matrix with thrombin and fibrinogen (TachoSil®), lineal durotomy centered over the lesion, finding a reddish, highly vascularized and friable tumor *(→ Image 4)* difficult to mobilize within the spinal canal.

The lesion was debulked with an ultrasonic aspirator *(→ Image 5)*, permitting visualization of the superior and inferior poles of the lesion and its microsurgical removal. After verifying hemostasis a hermetic dural suture was made and reinforced on the suture line with TachoSil® *(→ Image 6)*, and posterior laminoplasty with miniplates and screws *(→ Image 7, Video 1, available online at: https://youtu.be/OPnM-cDvoMo)*.

The anatomical pathology analysis showed a well defined neoplasm with an organoid growth pattern forming trabeculae, nests, perivascular pseudorosettes and pseudopapillae, organized around a prominent vascular network of thin-walled vessels, with positive immunohistochemical staining for chromogranin A and synaptophysin *(→ Image 8)*.

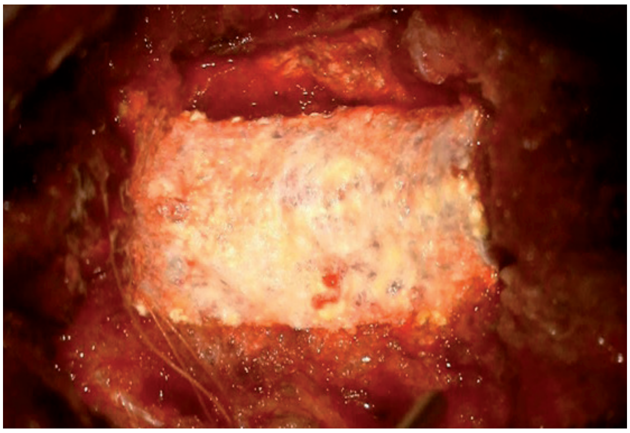

Image 6: Reinforcement of the suture line with TachoSil® to obtain a tight seal.

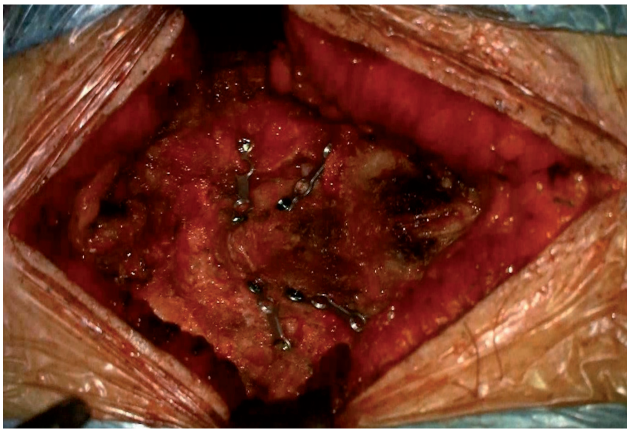

Image 7: Laminoplasty with mini-plates and screws.

Discussion

Neuroendocrine tumors are entities habitually found in the gastrointestinal or respiratory tract, or carotid glomus. They are characterized as being slow growth neoplasms of extra-adrenal paraganglionic cells, so they can synthesize and possible release peptides derived from the synthesis of biogenic amines (adrenaline, noradrenaline and dopamine)[1].

They are rare tumors with an annual incidence estimated at 0.07 cases per 100,000 inhabitants, described for the first time in 1972 by Lerman[2], being more frequent between the fourth and fifth decade of life, with slight predominance in the male sex. The most frequently presented symptoms are lumbar pain (43 %) and bilateral sciatica pain (23 %), although they can also present motor deficits, sensitivity or alteration of the sphincters and erectile disfunction[3].

The systemic symptoms derived from the release of catecholamines as in the pheochromocytomas are exceptional since they habitually are not capable of releasing the intracellular granules, and when they do their concentration tends not to reach sufficient concentrations in the blood[4].

The gold standard for the diagnosis is magnetic resonance imaging, where they are seen as iso or hypointense lesions in T1 and hyperintense in T2, with homogeneous contrast uptake, dependent on the spinal cone or on the horsetail roots/terminal phylum, so they are habitually confused with the presentation of more frequent lesions of similar characteristics such as neurinomas, myxopapillary ependymomas or meningiomas[5], which is why the preoperative diagnosis is exceptional, except in rare cases where the increase in catecholamines can be seen in urine or in cases in which the patient has had a prior neuroendocrine tumor in another location[6].

The treatment of choice is resective surgery. Special consideration of the hypervascular nature of these lesions must be made, which increases the risk of bleeding during surgery. Cases have also been described of adrenergic crises during the intraoperative manipulation of the lesion or in the immediate postoperative phase when a mass release of vasoactive amines is produced[7].

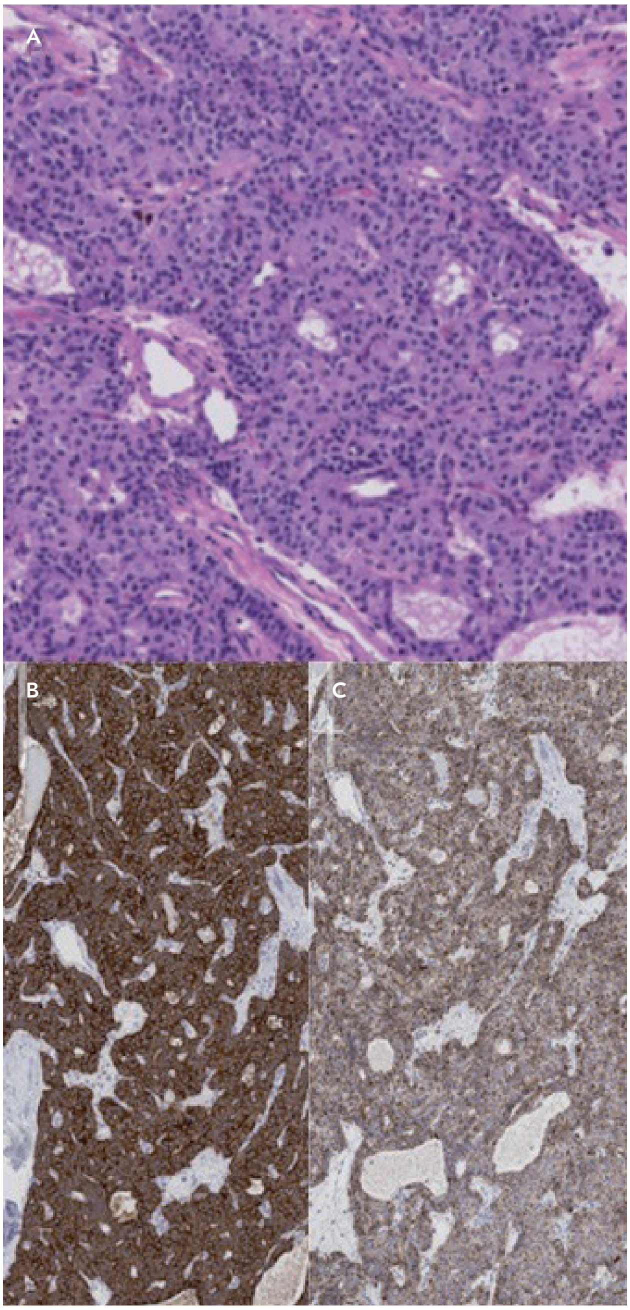

Image 8: Pathological anatomy. **A:** Well delimited neoplasm with an organoid growth pattern forming trabeculae, nests, perivascular pseudorosettes and pseudopapillae, organized around a prominent vascular network of thin-walled vessels. **B:** Synaptophysin positive. **C:** Chromogranin A positive.

Within the 2016 classification of central nervous system tumors of the World Health Organization (WHO), these are classified as grade I "mixed neuronal and neuroglial tumors"[8]. After resection, the prognosis is excellent with a reoccurrence rate of 2 %. In cases of partial resection they must be complemented with postoperative radiotherapy treatment, that obtains a reduction in the reoccurrence rate from 66 % to 20 %[9]. Follow-up will be for life, due to its slow growth, reoccurrences have been described up to 30 years after surgery. To date in only one case of malignancy has been described[10].

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14

Transnasal endoscopic approach for the resection of the petroclival fissure tumor: anatomical and surgical description

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Introduction

The petroclival fissure is formed by the union between the petrous portion of the temporalis and clivus, from jugular foramen to foramen lacerum. Among the lesions characteristic of this area are the chondrosarcomas, a group of heterogenous malignant tumors cartilaginous matrix producers.

The majority of the chondrosarcomas at the base of the skull are sporadic, low grade, and grow slowly from the synchondrosis eroding the surrounding bone. This growth pattern permits them to reach large dimensions, displacing neurovascular structures until symptoms appear.

To date, the optimal treatment of these tumors remains under debate. The objective is to offer the highest degree of resection to the disease-free survival rate with the lowest intra- and postoperative morbidity[1]. The introduction of endoscopic approaches has equaled or surpassed the degrees of transcranial resection surgery,
with a lower rate of minor complications, being especially useful to access the ventrolateral part of the trunk and petrous apex[2].

Once the resection is performed, the reconstruction becomes a challenge for the surgeon, especially in the case of intradural tumors. The advances in the techniques in the last 15 years[3], facilitated by the development of materials for the control of hemostasis and sealing, have reduced the incidence of cerebrospinal fluid fistula[7].

We present the case of a patient with a chondrosarcoma of the petroclival fissure with brainstem compression, who underwent surgery using an endoscopic endonasal approach (EEA).

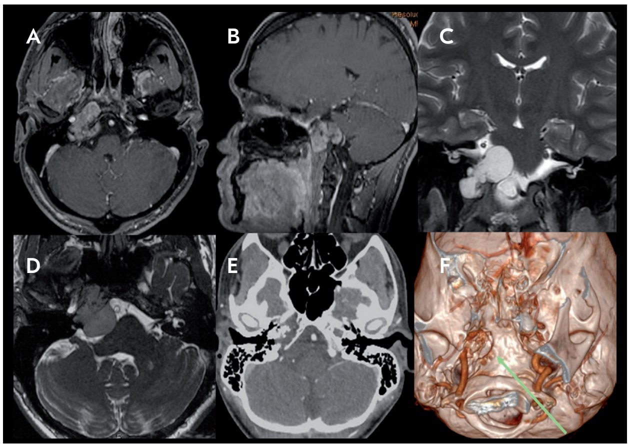

Image 1

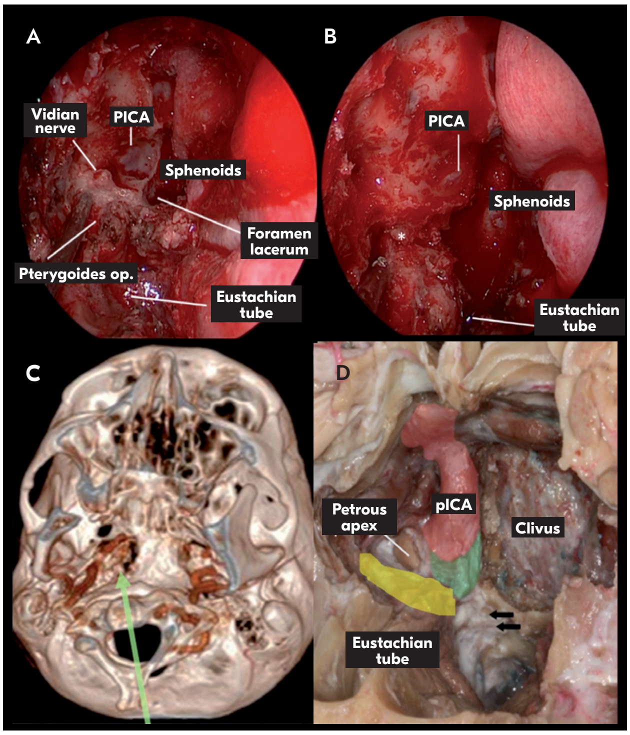

Image 2

Clinical case

Male of 28 years old without personal history that debuts with diplopia, and neurological deficits was admitted to our hospital. Magnetic resonance imaging (MRI) showed a lesion extending throughout the right petroclival fissure, contrast-enhancing, hyperintense in T2, with extension towards the prepontine cistern and compression of the brainstem. The computerized angio-tomography (CT) showed a lytic expansion of the petroclival fissure that previously displaced and elongated the internal carotid artery (ICA) *(→ Image 1).* With the suspicion of chondrosarcoma, an EEA was performed.

Surgical procedure

The patient was placed in supine decubitus position, with the head held with Mayfield, and under neuro-navigation. Neurophysiological monitoring was not performed. The surgery began with a right half and inferior turbinectomy and dissection of the left naso-septal flap[3], followed by a wide posterior septectomy. The mucous of the anterior nasal septum was covered with a right rotated flap "reverse flap"[4]. Right anterior and posterior ethmoidectomy, right antrostomy, resection of the wall posterior to the maxillary with exposure of the pterygopalatine fossa. Wide sphenoidectomy and reaming of intrasellar septa. After subperiostic dissection of the pterygopalatine fossa the right vidian nerve was identified, performing a transpterygoid approach with resection of the medial and partially lateral laminae of the pterygoid process[5].

The sphenoidal floor was reamed until the point of the petrous bone and foramen lacerum were identified. Beneath the foramen lacerum a yellow-brown tumor was identified, of soft consistency and avascular compatible with the presumed diagnosis. The ICA was skeletonized and the eustachian tube was disinserted, performing a partial resection and lateralization of the same *(→ Image 2).*

The approach was continued to the inferior lateral clivus, by reaming the supratubercular and tubercular compartments to access the most lateral area of the tumor, in the gulf of the jugular[6]. The bleeding of the inferior petrous sinus of the zone was controlled with thrombin gel (Floseal®) *(→ Image 3).*

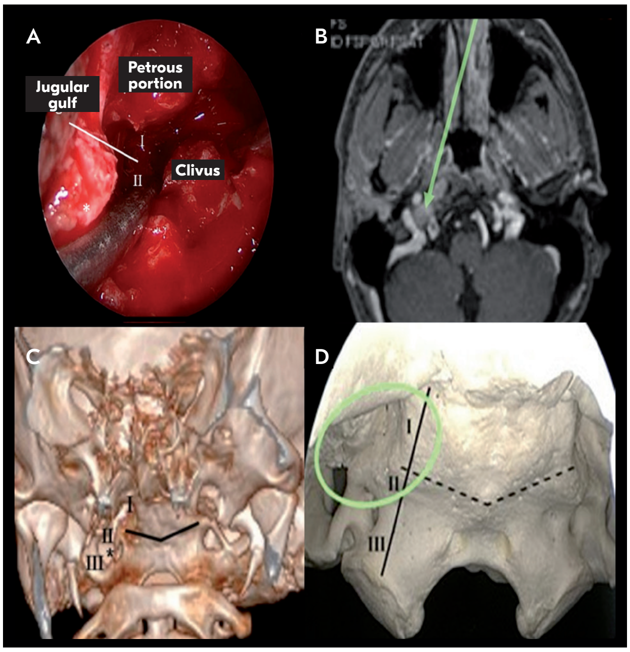

Image 3

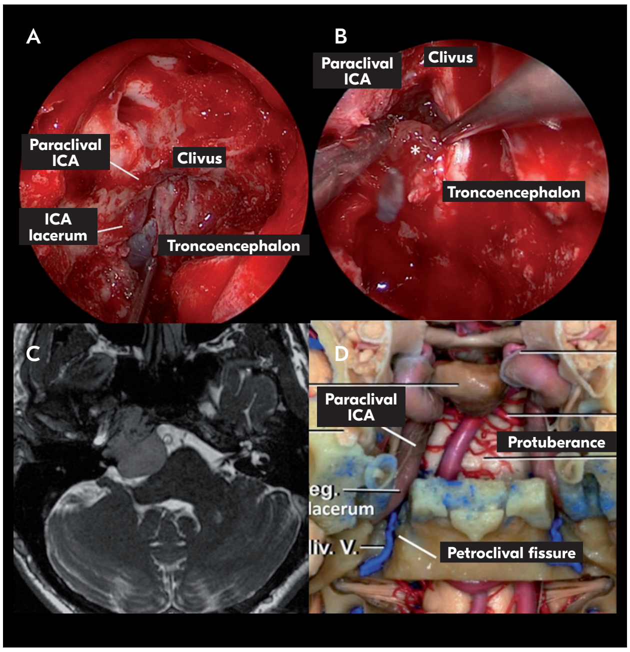

Image 4

Afterwards, the previously displaced paraclival ICA was skeletonized. The resection of the tumor was completed through the ICA and the petrous apex, resecting the tumor part the compressed the trunk *(→ Image 4)*. All tumors were either extra- or intradural. During the final phase a wide dural opening was produced. The defect was repaired and reconstructed with multiple layers of autologous fat, fibrinogen and thrombin adhesive matrix (TachoSil®), fascia lata and nasoseptal flap *(→ Image 5)*. Bioresorbable plugs and bilateral nasal packing were applied.

Postoperative evolution

The patient evolved favorably without deficits of cranial pairs. During the postoperative period the patient developed serous otitis and anesthesia of the right soft palate. The postoperative CT and MRI showed tumor resection surpassing 90 %, with decompression of the trunk and a remnant of the subcentimetric tumor in the posterosuperior zone of the ICA petrous *(→ Image 6)*. The patient began mobilization at 72 hours, with removal of the nasal plugs on the 6th day, without evidence of rhinolicuorrhea. Patient was discharged at home on the 7th day. The result of the pathological anatomy showed a WHO grade II chondrosarcoma. He will soon receive proton therapy.

Discussion

Tumors of the petroclival region pose a surgical challenge due to their depth and relationship to neurovascular structures. Traditionally the retrosigmoid approach has been used to reach them, which offers wide exposure to the pontocerebellar angle. It provides good exposure to tumors close to the internal acoustic meatus, however, it implies cerebellar retraction and the need to deal with cranial pairs. The middle fossa approach with anterior petrosectomy permits superolateral direct access, but requires temporal lobe and V3 retraction. It may be the election for the resection of intradural vascularized tumors (meningiomas). The EEA provides direct access to the clivus, the petrous apex and can be the election for extradural tumors (chordomas, chondrosarcomas) or drainage of cystic lesions. Its potential inconveniences are damage to the vidian nerve and the eustachian tube, as well as the risk of cerebrospinal fluid fistula[7].

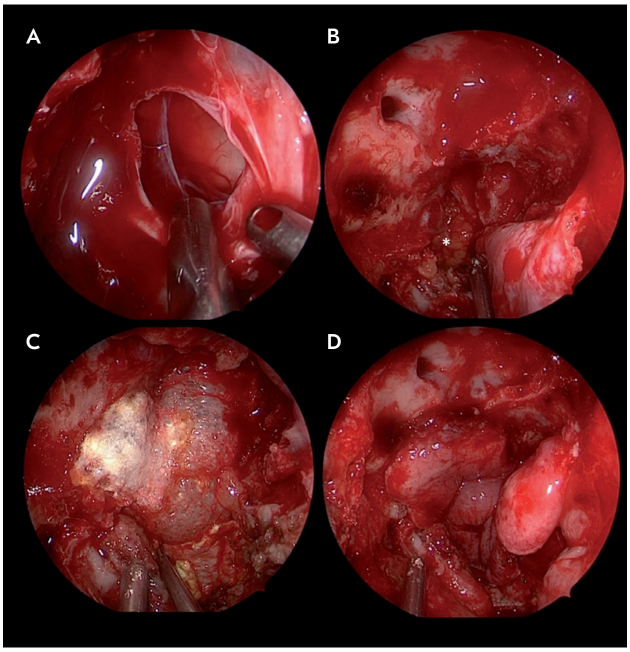

Image 5

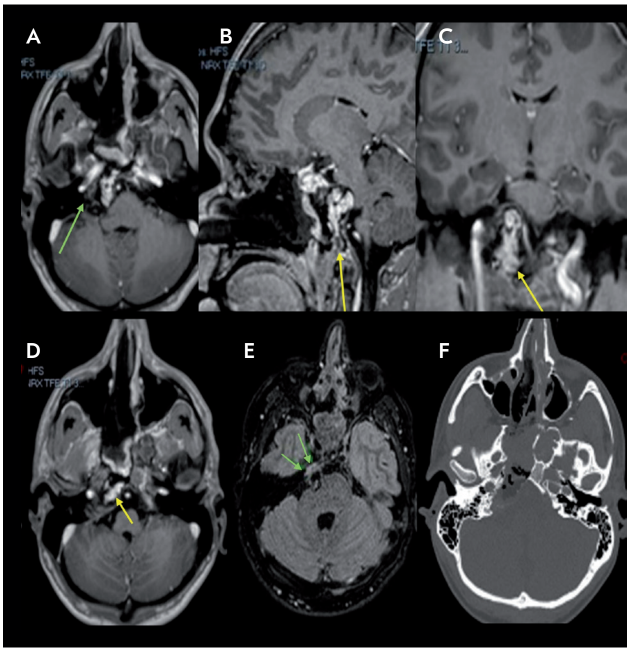

Image 6

Introduced in recent years, the transorbital endoscopic approach permits approaching lesions above the petrous apex an through the lateral orbital wall[8]. If it is combined with the EEA, a multiport approach permits the resection of up to 97 % of the petrous apex[9]. Disadvantages include its narrow working corridor and the risk of enophthalmos.

In the case presented, we decided to perform a transptergoid EEA to the inferior lateral clivus to approach the tumor along the entire length of the petroclival fissure and ventral area of the trunk[10]. The performance of a wide posterior septectomy increases the angles of access from the contralateral nose, being able to avoid a transmaxillary approach. Through the flap rotation "reverse flap" the stripped anterior mucosa is covered by using the contralateral nasoseptal flap, improving its recovery and reducing the formation of postoperative crusts[4].

Although it is a technically complex surgery, exhaustive knowledge of the anatomy permits the performance of a safer resection. In the transpterigoid approach it is important to identify the vidian nerve early, a reference to the ICA in the foramen lacerum. Following the canal in depth the VELPPHA area is found (vidian nerve and eustachian tube, foramen lacerum, petroclival fissure, phascia pharyngobasilaris)[11], a safe cartilaginous space where no neurovascular structures exist, and posterior limit of the transpterygoid approach[11]. To access the petrous apex various options exist:

1. medial transsphenoidal, ideal for lesions that expand posterior to the carotid into the sphenoid sinus[12],
2. intrapetrous, with reaming of the horizontal segment of the petrous ICA
3. Meckel's transcavum, through the quadrangular space, above the petrous ICA and lateral to the clival 7 ICA and
4. translacerum[13]. The combination of the maneuvers such as the mobilization of the paraclival ICA and the partial resection of the eustachian tube expand the petroclival region up to six times permitting it to be approached in its totality[13]. To do so the fibrocartilaginous anchors of the trunk and pharyngobasilar fascia to the foramen lacerum are sectioned, being able to provoke auditive alterations due to tubaric disfunction in 75 % of the cases[14].

With this maneuver direct access to the lateral and inferior region of the clivus is obtained, divided into three portions by the hypoglossal canal (supratubercular, tubercular and condylar compartments)[6]. The inferior petrosal sinus on its intracranial side runs parallel to the petroclival fissure extracranially. As we advance laterally to its opening in the jugular golf the bleeding will increase, which will be controlled with thrombin gels. The reaming of the superior compartments of the hypoglossal canal permit access to the lateral region of the petroclival fissure[6]. A good anatomical reference to locate the hyoglossus canal is the supracondylar groove. Special care must be taken to avoid lateral overextension to prevent damage to the parapharyngeal ICA and lower cranial nerves.

A good reconstruction of the defect is fundamental for the success of the surgery. The postoperative development of cerebrospinal fluid is an important complication, that lengthens the hospital stay and could lead to meningitis. The multilayer vascularized reconstruction techniques with hemostatic matrixes and sealants such as TachoSil®, autologous fat, fascia lata and endonasal flaps or grafts are efficient at reducing the postoperative fistula[15].

Conclusion

The EEA is a technique that is capable of obtaining a total or almost total resection of petroclival fissure tumors, with minimal morbidity and mortality. It is especially useful in tumors that extend to the petrous apex and with ventral compression of the trunk. The procedure must be performed by expert surgeons, with an excellent anatomical knowledge of the region. The multilayer reconstruction with hemostatic and sealant materials, autologous fat, and nasoseptal flaps, optimizes the closure and reduces the risk of postoperative fistula.

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15 Sealing of the ventricular wall in oncological surgery using human fibrinogen and thrombin

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Introduction

In glioma surgery with periventricular involvement, the need to perform supramarginal resection (beyond contrast uptake) to improve survival obliges the opening of the ventricular wall. In these patients, the probability of cerebrospinal fluid (CSF) fistula increases significantly and as a result, complications can cause the delay in the initiation of chemotherapy and radiotherapy. The surgical management of the opening of the ventricular wall tends to be generally limited in order to perform the best possible closure of the dura mater. In spite of this, the percentage of CSF fistula in patients with opening of the ventricular system continue to be the highest.

The combination of fibrinogen and human thrombin, in the form of a matrix and marketed as a pharmaceutical, has as its principal indication in neurosurgery as a hemostatic, or as a sealant of the dura mater, but there is no indication for the sealing of the ventricular wall.

In this clinical case, the use of the fibrinogen and thrombin matrix is described as a sealant of the ventricular wall, open both in the frontal horn and in the temporal horn, after the resection of a multifocal glioma, without producing CSF fistula in the clinical follow-up of the patient.

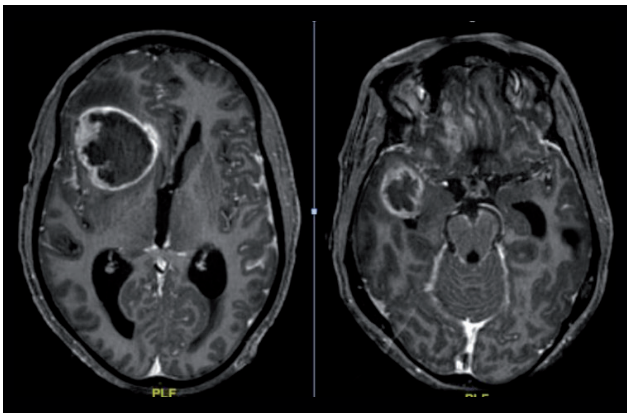

Image 1: Cerebral MRI, T1 with contracts multifocal malignant glioma. The image on the left shows an infiltrative lesion with contrast uptake at the frontal level with invasion of the frontal horn wall. The image on the right shows an infiltrative lesion with contrast uptake at the temporal level with invasion of the temporal horn wall.

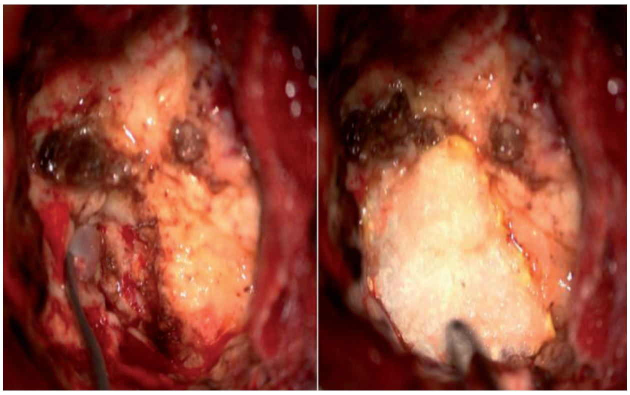

Image 2: Intraoperative view: The image on the left shows (dissector point) the right frontal horn opening with outflow of CSF. The image on the right shows the placement of the fibrinogen and thrombin matrix sealing the defect of the ventricular wall.

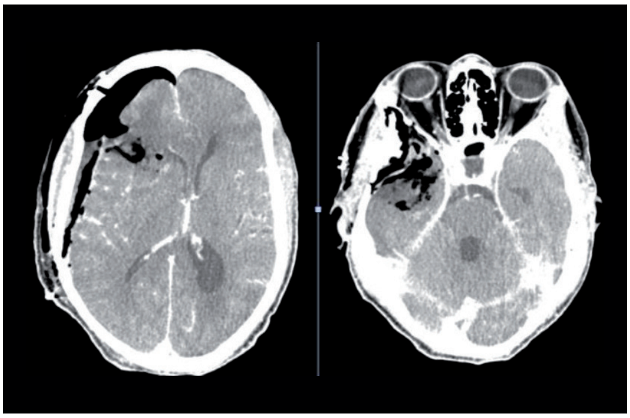

Image 3: Postoperative cranial CT with contrast. Complete resection of both infiltrative lesions and the opening of the ventricular system.

Clinical case

Patient of 63 years of age with clinical symptoms of tonic-clonical seizure and cognitive disorder of weeks of evolution. The cerebral magnetic resonance image (MRI) shows two infiltrative lesions, right frontal and temporal. Both lesions invade the ventricular wall of the right frontal and temporal horn. The lesions have contrast uptake, and the diagnostic orientation is multifocal malignant glioma, as no continuity was observed in the lesions *(→ Image 1).*

A right frontotemporal craniotomy was performed, and a supramarginal macroscopic resection of both lesions was planned, with the opening of both ventricles to obtain the required resection.

In *→ Image 2* the opening of the frontal horn is shown. The two ventricular openings were of 10 x 10 mm, and they were covered with a fibrinogen and human thrombin matrix of 20 x 20 mm *(→ Image 2).*

The dural closure using sutures was not perfectly hermetic, so it was also reinforced with another fibrinogen and human thrombin matrix.

The 24 hour postoperative cranial CT with contrast *(→ Image 3)* shows a total resection of both lesions (the patient could not tolerate a cerebral MRI).

In the follow-up of the patient during two months, the presence of subcutaneous CSF collections, pseudomeningoceles, or cutaneous CSF fistula were detected.

A total resection of the lesion was proposed, with the possibility of performing a supramarginal resection, under oncological fluorescence. In this surgical proposal the opening of both ventricular horns was assumed.

Discussion

The opening of the ventricular system leads to a high probability of CSF fistula, especially if the closure of the dura mater can't be perfectly hermetic. A surgical procedure destined to resolve the sealing of the dural opening exists, such that the effort to prevent CSF fistula is centered on the most hermetic closure of the dura mater possible, being able to use all types of dura mater patches, sealants or both. Even so, the percentage of CSF fistula in patients with opening of the ventricular system remains among the highest.

CSF fistula is a potentially serious complication, since it increases the probability of infection, and can delay the start of necessary treatments, such as radio therapy and chemotherapy, with the oncological repercussions.

The use of fibrinogen and human thrombin, in the form of a matrix, has as its principal indication in neurosurgery as a hemostatic, or as a sealant of the dura mater, but there is no indication for the sealing of the ventricular wall. Marketed as a pharmaceutical, the Spanish agency of medicines does not contraindicate its use at the level of the ventricular wall, its only contraindication is for intravascular use.

In this clinical case, two ventricular system openings were performed, and one closure by suture was not perfectly hermetic, leading to a very high probability of CSF fistula.

Currently, when the opening of the ventricle wall is presented during the surgical procedure, emphasis is placed on the hermetic closure of the dura mater, which, on some occasions is not obtained in spite of reinforcement of the dural closure with sealing agents. In this case, in spite of the double opening of the ventricular system and a dura mater that is not perfectly closed, the use of fibrinogen and thrombin as a sealant of the ventricular wall could have prevented the development of a CSF fistula.

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16

Use of TachoSil® for repair of cerebrospinal fluid fistula during endonasal endoscopic approach

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Introduction

The development of endoscopic surgery as an approach for the treatment of neoplasms at the base of the skull, has been the cornerstone of what today is denominated minimally invasive cranial surgery. The technological development, both from the endoscopic as well as the surgical instrument views necessary to perform these approaches, has had an exponential evolution in the last twenty years, which united with the knowledge of the neuroanatomy, has permitted the treatment of numerous pathologies in deep locations reducing the morbidity of the conventional open approaches.

However, endoscopic surgery at the base of the skull is not exempt from complications, one of the most feared being the cerebrospinal fluid (CSF) fistula. According to the literature, the prevalence of this complication ranges between 2 % registered in the pituitary adenomas and of 5 % in the cases of major complexities such as craniopharyngiomas, meningiomas and chordomas with intradural extension[1,2].

The development of diverse multilayer closure techniques using both autologous tissue as well as synthetic plasties has permitted the approach of the CSF fistulas with a greater guarantee of success, which has resulted in a lower rate of postsurgical complications[3], and a shorter hospital stay.

We present the case of a CSF fistula secondary to a rupture of the selar diaphragm during the endoscopic resection of a pituitary adenoma, that could be satisfactorily resolved with the use of TachoSil®.

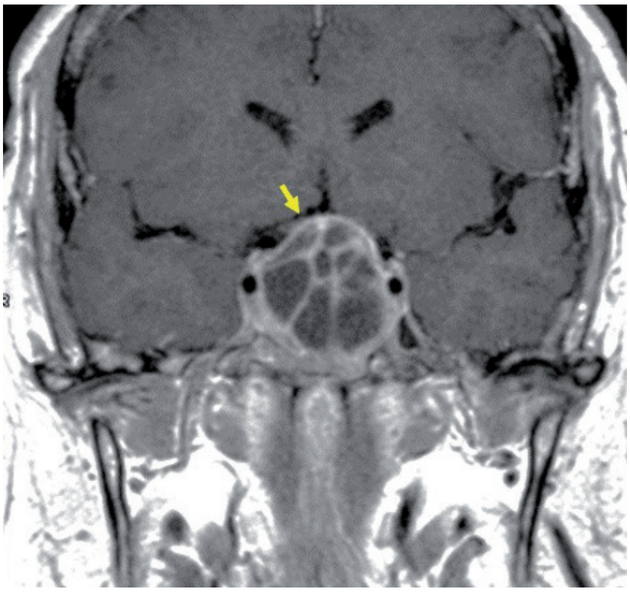

Image 1: Coronal slice of magnetic resonance imaging in T1 boosted with gadolinium. There is evidence of a cystic-necrotic selar tumor extending cranially and compressing the optic chiasm (yellow arrow). Findings that suggest a pituitary macroadenoma.

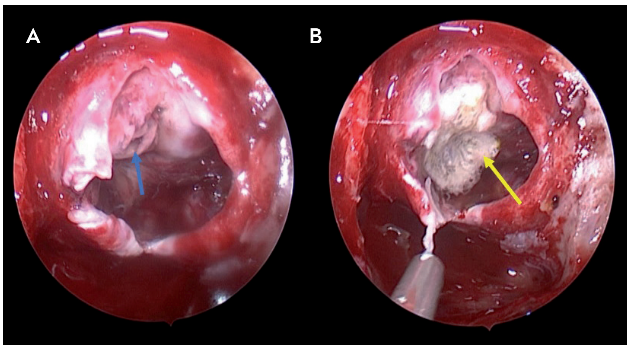

Image 2: A: After the resection of the adenoma there is evidence of outflow of CSF through the selar diaphragm defect (blue arrow). **B:** A piece of TachoSil® (yellow arrow) can be seen covering the diaphragm defect.

Clinical case

51-year-old female patient, without a history of interest, was referred for consultation after presenting symptoms of five months evolution consisting of asthenia and loss of peripheral vision. The neurological examination revealed only a bitemporal hemianopsia, which was later confirmed by a campimetric study. The hormonal analysis showed partial secondary suprarenal insufficiency, with the rest of the axis being normal.

Based on the clinical and analytical findings a cerebral magnetic resonance imaging was performed that showed a selar lesion of 37 mm at maximum diameter compatible with pituitary adenoma. This lesion extended into the suprasellar cisterns, displacing the optic chiasm superiorly and compressing the medial wall of the cavernous sinuses laterally without invading them *(→ Image 1).*

After explaining the surgical indication and obtaining consent on behalf of the patient a programmed resection of the tumor was performed using an endoscopic endonasal transsphenoidal approach. In the final phase of the resection a tiny tear occurred in the selar diaphragm with the resulting intraoperative CSF fistula *(→ Image 2A).*

After completing the resection of the adenoma and correctly identifying the defect in the diaphragm we proceeded to repair the fistula following the technique we describe below. In the first place, we measure the size of the defect using as a reference a 1 x 1 cm lens and cut a piece of TachoSil® a few millimeters bigger than the size of the defect.

Afterwards we introduce the TachoSil® folded over its active side (yellow face) to prevent its adherence to other nasal structures and, once we have reached the sella turcica we extend it with the help of a dissector applying its active surface over the defect of the selar diaphragm (it is convenient to use dry instruments to prevent the TachoSil® from adhering to them).

Continuing, with the help of a moistened swab, we got pressure on the non-active side (white face) of the TachoSil® (Corza Medical GmbH) during three minutes. After removing the swab we verify that the synthetic plasty is adhered to the selar diaphragm *(→ Image 2B)* completely sealing the defect (at this point we checked for the absence of fistulas after the development of Valsalva maneuvers).

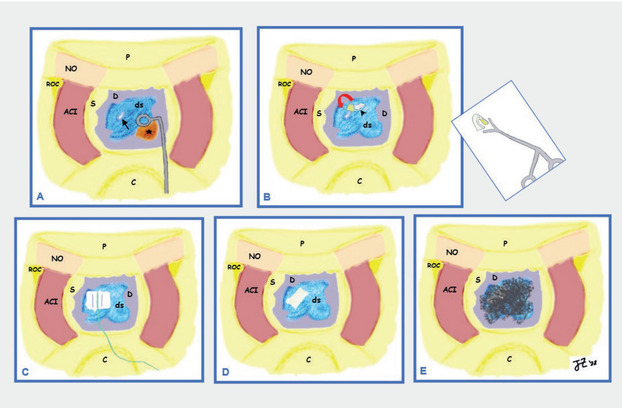

Image 3: A: As we complete the tumor resection (*) we identify a defect (black arrow) in the selar diaphragm. **B:** We place the TachoSil® (head of the arrow) over the diaphragm defect applying, as the red arrow indicates, the active side of the same (yellow side) directly over the diaphragm. To be able to introduce the TachoSil® preventing its adherence to other structures we recommended introducing it with the active side folded as indicated in the small image attached to the right **C:** We apply pressure over the TachoSil® with a humid swab during two minutes. **D:** After removing the swab it can be seen that the TachoSil® is completely adhered to the selar diaphragm without evidence of cerebrospinal fluid outflow. **E:** Finally we fill the sella with Surgicel®.

Abbreviations: ICA: Internal carotid artery; **C:** clival recess; **D:** open dura mater; **ds:** selar diaphragm; **ON:** optic nerve; **P:** sphenoidal planum; **OCR:** optical-carotid recess; **S:** base of the open sella turcica

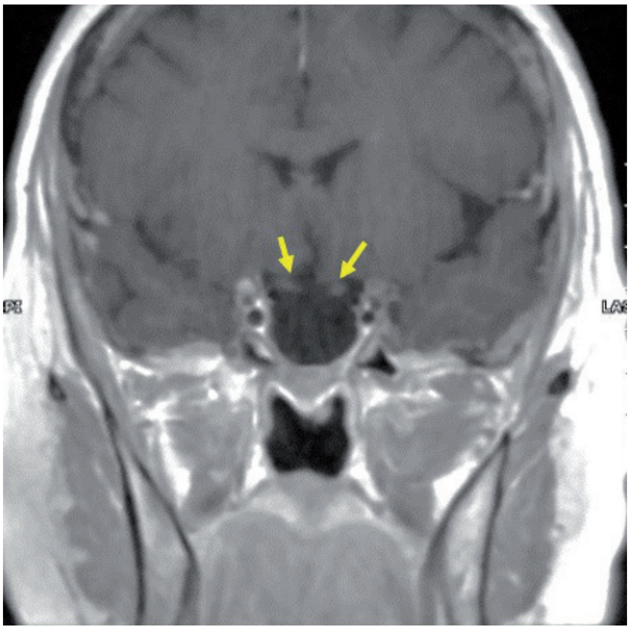

Image 4: Coronal slice of magnetic resonance imaging in T1 boosted with gadolinium. View of the complete resection of the selar tumor with decompressing of the visual path (yellow arrows).

Finally we fill the resection cavity with Surgicel® (Ethicon Inc, Johnson & Johnson) *(→ Image 3)*, we cover the selar defect with a fragment of mucous and insert a nasal plug with NasoPore® (Stryker) and Merocel® (Medtronic).

The postoperative period was without incidents and the patient was discharged the fourth day of the intervention without evidence of CSF fistula. In the controls performed at six months and one year it was possible to verify a recuperation of the field of vision and a complete resection of the pituitary macroadenoma *(→ Image 4)*.

Discussion

The development of endoscopic skull base surgery, with the rise in the last decade of the expanded approaches[4], has permitted surgical procedures on tumors that until recently were unresectable or implied the performance of craniofacial dismantling with a high degree of morbimortality. However, the increase in the rate of resection has accompanied the growth in the number of CSF fistulas that are difficult to repair.

We can affirm that the cerebrospinal fluid fistulas constitute one of the principal battle horses of neurosurgeons and otorhinolaryngologists dedicate to approaching skull base lesions and that, the principle milestone in the last thirty years to be able to treat them has been the development of pediculated nasoseptal flaps that have permitted the reduction of the rate of fistulas similar to those observed after open surgeries[5]. However, the use of isolated flaps has proven to be insufficient for the closure of fistulas due to diverse factors that can cause their failure such as the mobilization of the flap due to massive outflow of CSF, necrosis of the same in the case the vascular pedicle is accidentally damaged or the development of a unidirectional valvular mechanism that permits the entrance of air at the intracranial level. Therefore, the multilayer closure has become the treatment of choice for the repair of CSF fistulas located at the base of the skull.

Today, multiple multilayer reconstruction techniques have been published, many of which use heterologous plasty, generally Duragen® (Integra Sciences), prior to autologous flap[6]. In our centers, in the first place we use TachoSil®, a collagen matrix covered on one of its surfaces with fibrinogen and thrombin molecules that, in contact with fluids, precipitate a chemical reaction that originates covalent bonds between the collagen matrix and the wound surface (in our case, with the selar diaphragm). The adherence that is produced permits a strong seal of the diaphragmatic defect which we consider, is the basis for the posterior success of the flap since TachoSil® stops the flow of CSF permitting in the days posterior adequate healing of the autologous tissue. It is important to highlight in this point that, the use of TachoSil® associated to a free mucous flap is sufficient for the endoscopic repair of selar diaphragm defects as in the case we have presented, however, in the cases of high flow fistulas it is necessary to perform a closure with a greater number of layers (fat, fascia, lata) and to use pediculated flaps[7].

It is necessary to be aware that the great adherence to the surfaces offered by TachoSil® make its manipulation difficult, especially in endoscopic endonasal surgery where the work fields can occasionally be very narrow. Nonetheless, the work is facilitated following the advice indicated in the clinical case (work with dry instruments and do not unfold the active surface until it is close to the defect we want to cover) and in general, we did not observe an increase in the time of the surgical interventions. In addition, we have successfully used this technique in two different neurosurgery services in national territory proving that this technique presents a steep learning curve, that is to say, few surgeries are required to dominate it.

Finally it must be mentioned that TachoSil® was approved by the EMA since 2017 as a dural sealant that demonstrated in a multicentric randomised clinical trial a rate of fistulas after open cranial surgeries[8]. In this work we defend its utility as a sealant in endonasal endoscopic surgery following the line of other recently published articles[9].

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17

Rupture of the intracavernous internal carotid artery as a complication of endoscopic transsphenoidal surgery

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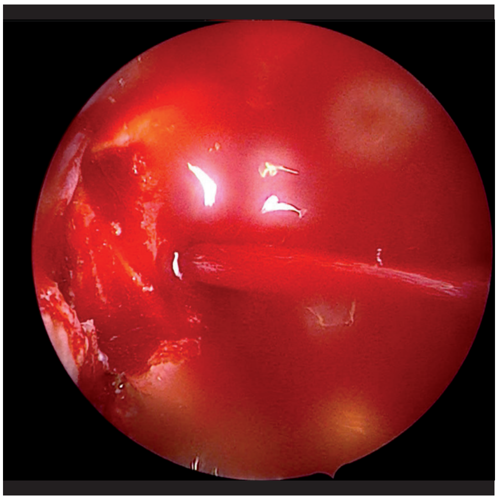

Image 1: Accidental rupture of the right ICCA during the reaming of the sella turcica.

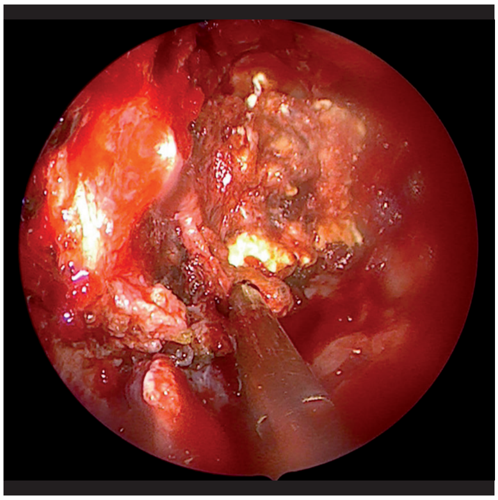

Image 2: Temporary control of bleeding by use of swab plugs to achieve hemodynamical stabilization.

Introduction

The endonasal endoscopic approach is the most frequently used procedure today in the majority of the centers for pituitary lesion resections. Although it is considered to be less invasive than transcranial surgery, it is not exempt from risks, that, although they are infrequent, can be potentially serious, among them damage to the nervous or vascular structures, cerebrospinal fluid fistula, postsurgical meningitis, etc. Within these, the vascular complications tend to be uncommon, with the most frequent being a lesion to the intracavernous internal carotid artery (ICCA) (0.8 – 1.4 %)[2].

The internal carotid artery is divided into seven segments which stems at the level of the fourth cervical vertebra – cervical (C1), petrous (C2), lacerum (C3), cavernous (C4), clinoid (C5), ophthalmic (C6) and communicating (C7), as it has been mentioned, the cavernous is the most frequently damaged in transsphenoidal approaches[3], with a mortality rate of 10 %[4].

Although it is a complication little described in the literature, it has great relevance due to the associated morbimortality and the difficulty for its early treatment, considering that it is an endoscopic approach. It can have very severe consequences both immediate, due to the severity of the hemorrhage (shock, cerebral ischemic infarction, severe neurological damage, death...), as well as in the mid and long term (formation of cavernous carotid fistulas and pseudoaneurysms).

Currently, very few cases are described in the literature, so its incidence is probably underestimated. This is why standards or agreements for its intraoperative treatment do not exist. However, it is necessary to know all of the existing alternatives for its quick, early and efficient management, and although it is an uncommon complication, its consequences and treatments must be known.

Clinical case

We present the case of a 33 year old patient with Cushing's Disease secondary to a pituitary microadenoma, with an indication for a resection using an endonasal endoscopic approach, with the complication of an accidental rupture of the right ICCA during the reaming of the sella turcica *(→ Image 1)*.

Initially, the point of origin of the hemorrhage was sought, to do so it was necessary to use two aspirators. Once it is located, with the use of swabs as temporary plugs, bleeding is contained and the patient is hemodynamically stabilized *(→ Image 2)*.

To perform the definitive plugging in an adequate way packing was made using TachoSil® (Corza Medical GmbH), soaked with Surgiflo (Ethicon, West Somerville, New Jersey, United States), Surgicel (Ethicon, West Somerville, New Jersey, United States) and swabs.

Afterwards, once the hemorrhage was detained, it was reinforced with a balloon taponade to guarantee the adequate sealing and transfer the patient to the arteriography room to perform an urgent cranial CT to discard immediate complications. Once the stability and absence of active hemorrhage were confirmed, the cerebral arteriography was performed to verify the existence of the hemorrhagic point that could be treated endovascularly or by arterial occlusion.

Likewise, the flow through the left ICA by the anterior communicating artery was verified, as a prevention of a possible occlusion of the right ICA, both temporarily for the definitive treatment of the pituitary and carotid lesions, as well as definitively in the case of not being able to control the bleeding in the long term.

Once the complications were discarded, the tamponade remained in place for a week and the patient was reintervened, with the performance of an intraoperative arteriography by the Vascular Neuroradiologist in a hybrid surgical room. First, the excision of the pituitary tumor was completed (which was unable to be performed in the first surgery), and afterward the repair of the wall of the RICA was performed. To do so, it was initially necessary to temporarily occlude the flow of the RICA by inflating an intracarotid balloon and in this way completely remove the packing to discover the point where the arterial wall was injured. For the definitive sealing fragments of the patient's quadriceps muscle and fascia lata were used, as well as TachoSil® and Surgicel®. Afterwards, a new intraoperative control using arteriography showed a dubious image of a pseudoaneurysm. We proceeded to finish the sealing and could wake up the patient without any incidents.

At three weeks after the surgery, a new control by arteriography was requested, showing no defects in the wall of the vessel, and discarding the previous suspicion of a pseudoaneurysm. At the time of discharge, the patient had no neurological or hormonal deficit.

Discussion

As is well described in the majority of the articles, the best way to treat this type of complications is the prevention of them by exhaustive planning and the use of tools such as Neuronavigation or Doppler. However, in spite of all of this, a vascular lesion can take place. Some classifications according to type and size of the lesion have been described, as well as the different techniques that can be used to stop the hemorrhage[5]:

- Damage to a branch or directly less than 2 mm.
- Direct damage greater than 2 mm:
  - → Penetrating damage that includes one or more layers of the artery.
  - → Damage to the three layers of the artery.

When these types of lesions occur, the most important step is to achieve an adequate hemostasis. Traditionally, to be able to do so, arterial hypertension measures were performed, elevating the head, manual compression of the external carotid artery at the neck level, and even cervical approaches for the compression or direct closure of the ipsilateral carotid, maneuvers the had numerous complications such as strokes or even death. To achieve this, packing is currently the most accepted form of hemostasis.

However, it is a maneuver that is not exempt from risks, since excessive packing can lead as well to stenosis or even complete occlusions of the ICA, as well as increase the risk of forming pseudoaneurysms (up to 60 %)[6]. The possibility of endovascular treatment of this type of lesion also exists through the placement of coils, or balloons, for which it is necessary to verify that there is adequate contralateral arterial flow; or the placement of stents as well, that supposes the patient will maintain an antiaggregant treatment for life to reduce the risk of thrombosis.

If there is a good view of the defect, in damages less than 2 mm it is possible to try to perform direct coagulation of the vessel by using bipolar (although this has been associated with a greater risk of repeated bleeding), or repair by clipping with lower risk of ischemia, both extremely difficult techniques to perform due to the type of approach (endoscopic view, limited work space), as well as due to the flow of the arterial hemorrhage. In those cases where damages are greater than 3 mm, or a penetrating lesions exists there is an elevated risk of ischemia, such that, if it is possible, clipping of the vessel can be attempted, or even direct suturing has been described, although this leads to an increased risk of posterior stenosis.[6,7]

Just as we have described in out case, it is equally important in the management of this complication to carry out an adequate hemostasis both at the acute moment, as well as at the time of the definitive treatment. According to other case descriptions in the literature, as just as it was in our concrete case, having available various types of medicated matrixes permits control of hemorrhage at the acute moment, obtaining hemodynamic stabilization, and in this way avoid a massive hemorrhage that could have fatal consequences for the patient[6].

This is why knowledge of the different types of these materials, as well as their indications and uses is essential in neurosurgery, and we consider their availability of vital importance in hospital centers.

The direct lesion of the ICA wall during the transsphenoidal approach is an infrequent complication, the knowledge is important, and the management of the hemostatic materials for this type of intervention, since in a short time, a high flowing hemorrhage takes place in a tiny surgical field. The existence of hybrid operating rooms, multidisciplinary teams with knowledge of neurovascular pathologies to carry out an adequate diagnosis, assessment of the damages, and being able to offer the most adequate treatment for each patient are equally important.

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18 Excision of an intradural extramedullary lesion using double layer dural closure technique

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Introduction

We present a case of a patient with an intradural extramedullary dorsal lesion. In this type of surgery, after the excision, it is of great importance to assure a good dural closure to avoid cerebrospinal fluid fistulas[1]. We placed TachoSil® in an inverted subdural position and performed a suture of the dura mater in a double layer with this objective.

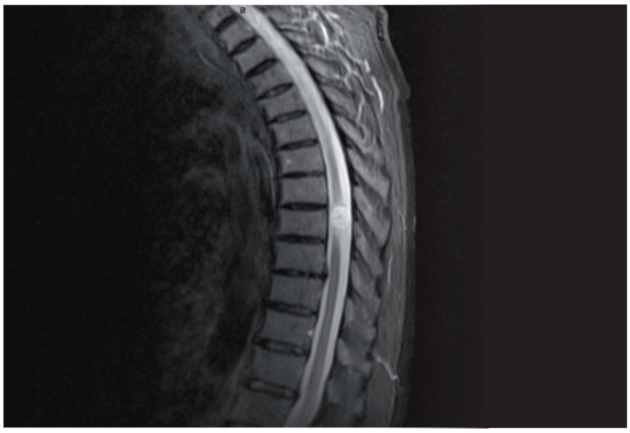

Image 1: MRI sequence of the dorsal column, enhanced at T2, that shows a rounded nodular lesion, intradural extramedullary, compatible with schwannoma or meningioma as primary possible diagnosis.

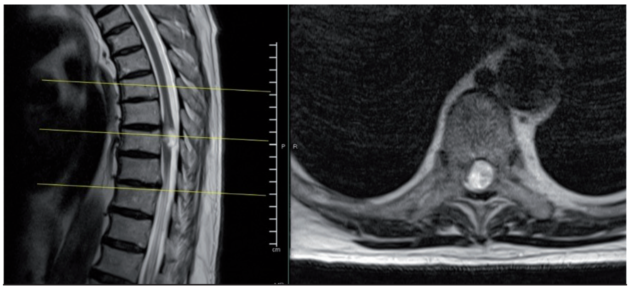

Image 2: Correlative sagittal and axial MRI sequences, enhanced at T2, showing a rounded nodular lesion, that displaces the spinal cord to the right and compresses it.

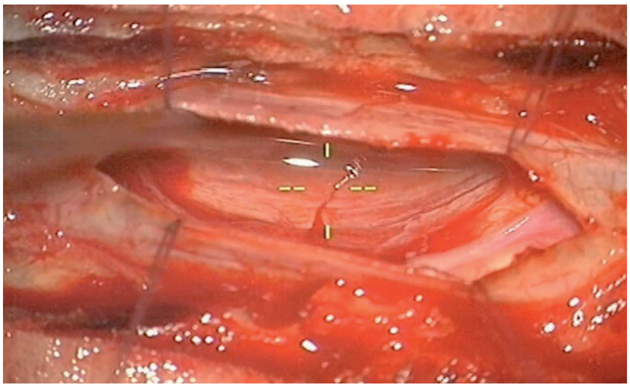

Image 3: Posterior approach to the dorsal column. After laminectomy centered over spaces T7 — T8, the opening of the dura mater is performed. An indurated, grayish, intradural extramedullary lesion is identified, which appears to be dependent on the left T8 root. Debulking begins assisted with ultrasonic aspiration.

Clinical case

Motive for consultation

Loss of strength in lower limbs.

Personal background

- No allergies known to medications.
- Ex smoker.
- Arterial hypertension.
- Chronic obstructive pulmonary disease.
- Prior surgeries: open prostatectomy, perianal abscess, cataracts in both eyes, neurinoma L3 — 4.

Current illness

Male of 78 years of age with symptoms of subacute lumbago and loss of strength in inferior members. On examination, motor balance in inferior members is registered a 1/5 at the proximal level and 2/5 at the distal level, bilateral, with decreased sensitivity and abolished osteotendinous reflexes.

A dorsal column magnetic resonance image showed an intradural extramedullary lesion at the D8 level *(→ Image 1)*, with a nodal aspect, rejecting the medullary cord to the right *(→ Image 2)*, compatible with schwannoma as the first diagnostic option.

Surgery through laminectomy and excision was proposed, explaining the risk, benefits and alternatives. The patient understood and accepted.

The patient was treated under general anesthesia, in prone decubitus position, making cutaneous incision centered over space T7 — T8, with subperiosteal dissection and laminectomy T7 — T8 *(→ Image 3)*.
A durotomy on the middle line was performed exposing the lesion dependent on the left D8 root. Initially a debulking technique was performed on the lesion with an ultrasonic aspirator, subsequently completing the resection of the lesion through subperiosteal dissection sectioning of the involved root *(→ Images 4 and 5)*.

After careful hemostasis was achieved, closing maneuvers were started. An inverted patch of TachoSil® was placed in the subdural position *(→ Image 6)*. Afterwards, a double layer dural plasty was performed (first plane in continuous suture, second plane with loose stitches) with Prolene 7/0 *(→ Images 7 and 8)*.

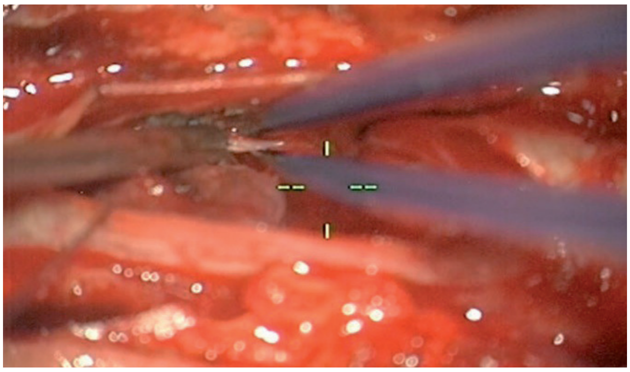

Image 4: After completing the debulking, the lesion is dissected from the adjacent roots, identifying, coagulating and sectioning the left D8 root from which it originated.

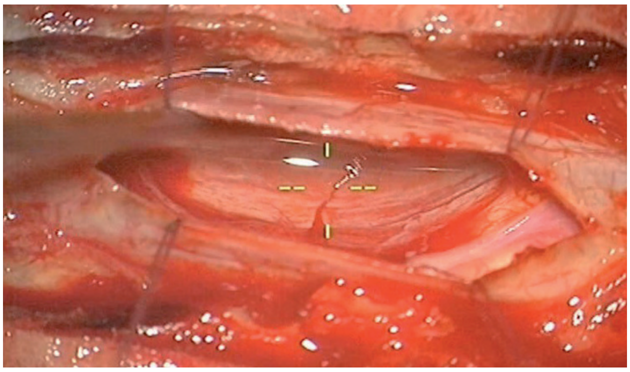

Image 5: Surgical bed after completing the excision of the lesion and finalizing the hemostasis. The spinal cord is displaced due to the effect of the mass generated by the lesion.

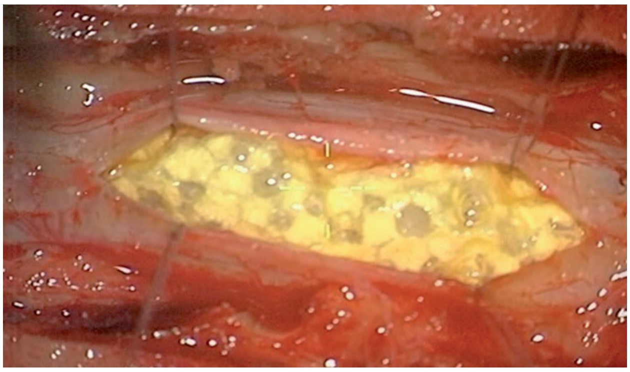

Image 6: Placement of the inverted TachoSil® in the subdural position.

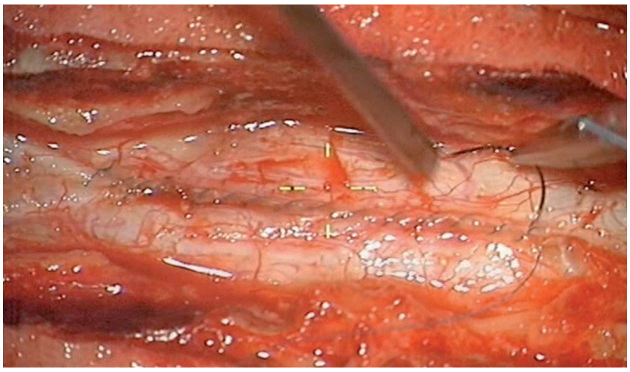

Image 7: Close-op of the dural closure, continuous suture of non-absorbable monofilament.

Finally the closure was completed in planes (→ *Images 9 and 10)* and a sample is sent for histological analysis.

Evolution

The patient was extubated in the operating room without incidents. Afterwards he was admitted to the intensive care unit. The neurological examination was superimposable on the presurgical. After completing the control period he was transferred to the hospital ward.

Rehabilitation was initiated during the hospital stay, improving motor balance in lower limbs up to 3/5 bilaterally.

The surgical wound showed a good evolution, without stains or accumulations. Once the postoperative control period was finalized, and given the clinical status of the patient, he was derived to a specific center to continue with rehabilitation.

Discussion

Cerebrospinal fluid (CSF) fistulas are a known complication in spinal tumor surgeries, like in these cases, durotomy is inevitable[1,2].

Their appearance increases the morbidity, the hospital stay, lengthens the period of immobilization, and predisposes the patient to complications associated to this situation.

Repairing dural defects primarily is important to avoid the appearance of postsurgical fistulas[1,2].

Different techniques and materials for dural closure have been proposed[2].

We propose a closure technique placing an inverted patch of TachoSil® in the subdural position, posteriorly closing the dura mater in two planes: the first plane in continuous suture using non-absorbable monofilament; and afterwards the second plane with loose stitches, also with non-absorbable monofilament (→ *Image 8)*. We believe this closure technique reduces the possibility of the appearance of postsurgical CSF fistula, resulting in a more favorable evolution in this type of patient.

New studies are required to confirm the effectiveness of this technique to reduce the frequency of appearance of postoperative CSF fistula after spinal tumor surgery.

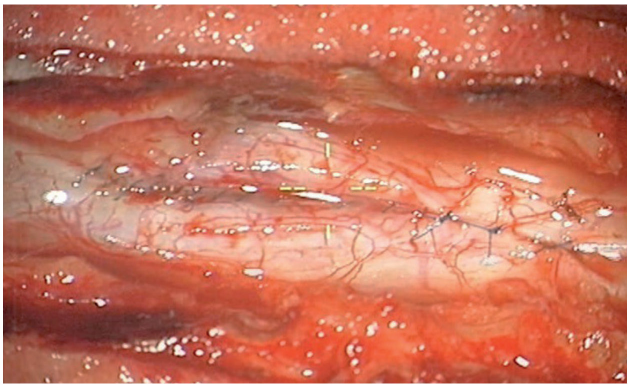

Image 8: Initiation of the second plane of the dural closure, with loose stitches, also with non-absorbable monofilament. This second plane hides the first suture.

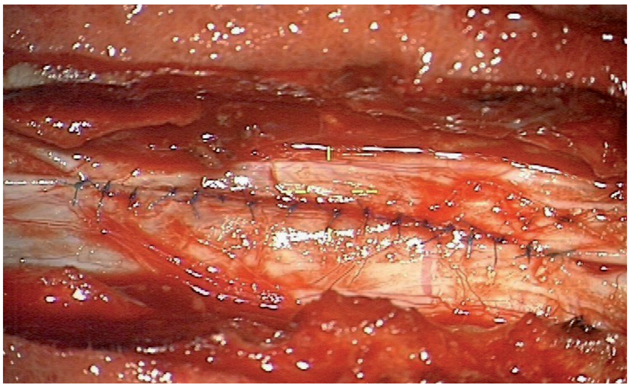

Image 9: Final result of the dural closure after performing the double layer technique.

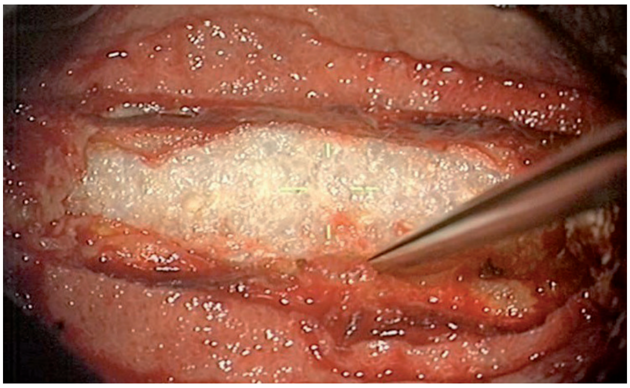

Image 10: Application of TachoSil® over the dural suture as a sealing reinforcement of the same and hemostasis of the epidural space.

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Right paraclinoid aneurysm. Application of TachoSil® with papaverine in the surgical bed to prevent vasospasm

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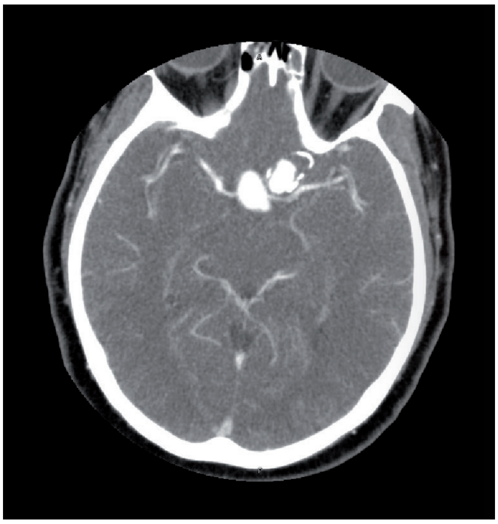

Image 1: Body CT performed on a patient with systemic mastocytosis. In this axial slice we incidentally observe the presence of two internal carotid artery aneurysms.

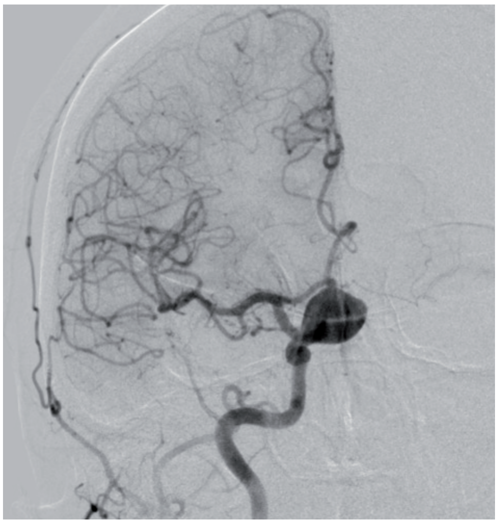

Image 2: The angiograph after injection of contrast in the right internal carotid artery. An aneurysm dependent on the paraclinoid segment is observed.

Introduction

We present a case of a patient with a right internal carotid artery aneurysm, in the paraclinoid portion, which was operated by craniotomy and clipping. During the surgical intervention, after the clipping, TachoSil® soaked in papaverine, was applied to the surgical bed to prevent vasospasm.

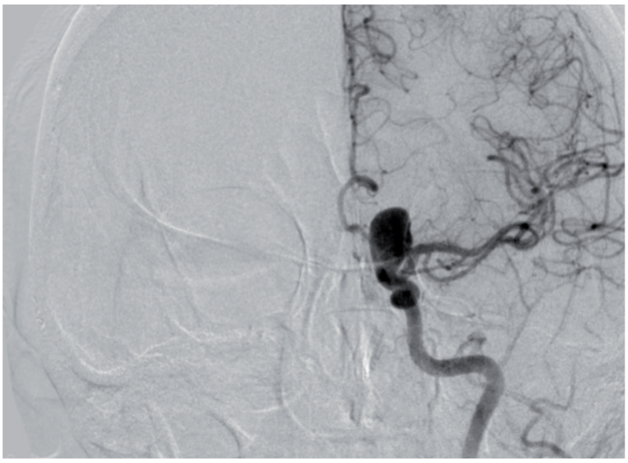

Image 3: Angiography after injection of contrast in the left internal carotid artery. Aneurysm dependent on the paraclinoid segment is observed.

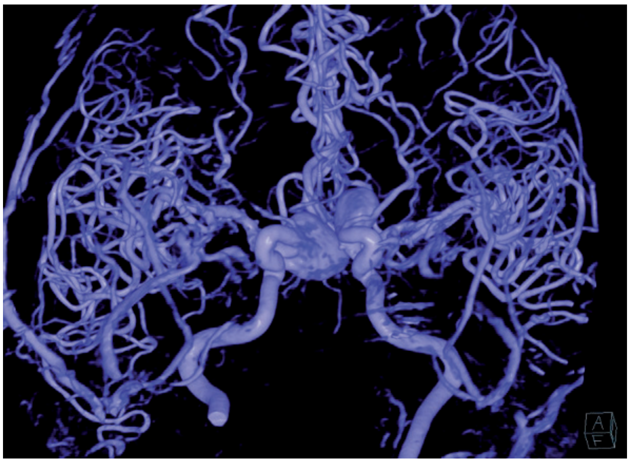

Image 4: Angiographic reconstruction that shows aneurysms of the internal carotid artery, bilateral, dependent on the paraclinoid segment.

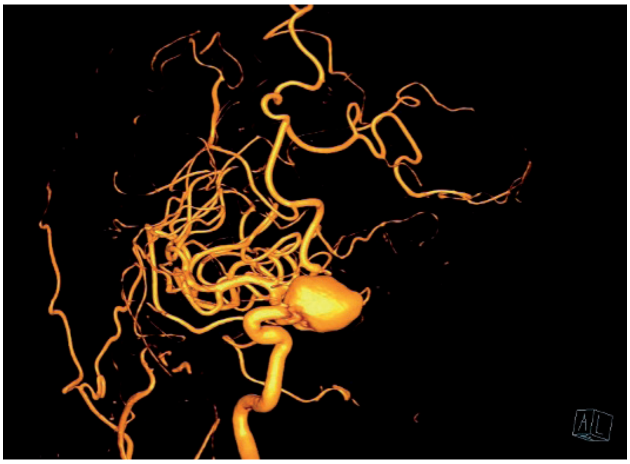

Image 5: Angiographic reconstruction of the series of the internal right carotid artery, where we observe the aforementioned paraclinoid aneurysm.

Clinical case

Female patient of 57 years old.

Motive for consultation

Patient assessed in external consultation due to the incidental finding of cerebral aneurysms.

Personal background

- No known allergies to medication.
- Arterial hypertension being treated with pharmaceuticals.
- Active smoker.
- Hypothyroidism in replacement therapy.
- Mastocytosis with cutaneous lesions without systemic involvement.
- Surgical history: conization, appendectomy, tonsillectomy, reduction of the left breast.

Current illness

Bilateral paraclinoid saccular mirror aneurysms. was seen in body CT *(→ Image 1).*

Admittance to our center for the performance of a diagnostic angiograph *(→ Images 2 – 5)* confirming the existence of a polylobulated saccular, in both internal carotids in the paraclinoid segment.

An occlusion test was performed that demonstrated intolerance to sacrifice of both internal carotids.

After assessing the case, it was decided to offer surgical treatment, starting with the aneurysm on the right side in the first place; planning a posterior second stage treatment of the aneurysm of the left side. The risks and expected benefits were explained to the patient, as well as the possible alternatives. The patient understood and accepted, signing the informed consent form.

Preanesthetic assessment without contraindications for the intervention.

The patient was treated with a right peritoneal craniotomy *(→ Image 6)*, with additional reaming of the sphenoidal wing *(→ Image 7)* and anterior extra-dural clinoidectomy; with control of the internal and external common carotid artery, at the cervical level.

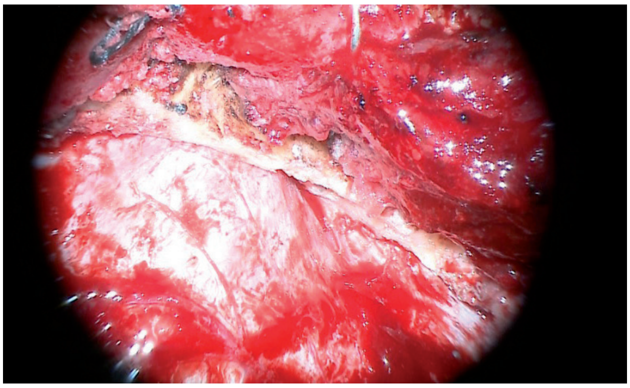

Image 6: Right peritoneal craniotomy.

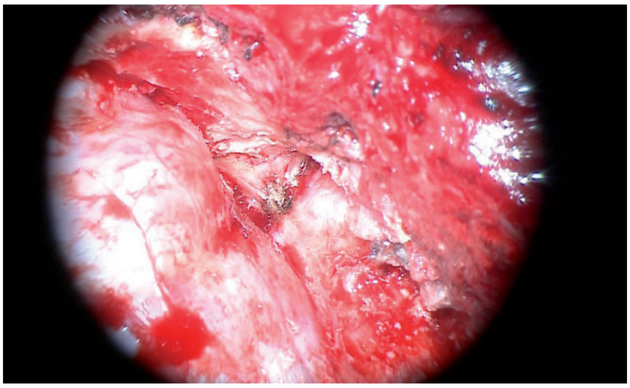

Image 7: Additional reaming of the sphenoidal wing.

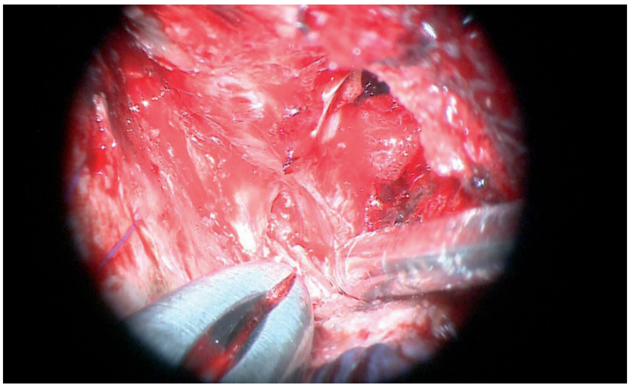

Image 8: Anterior extradural clinoidectomy.

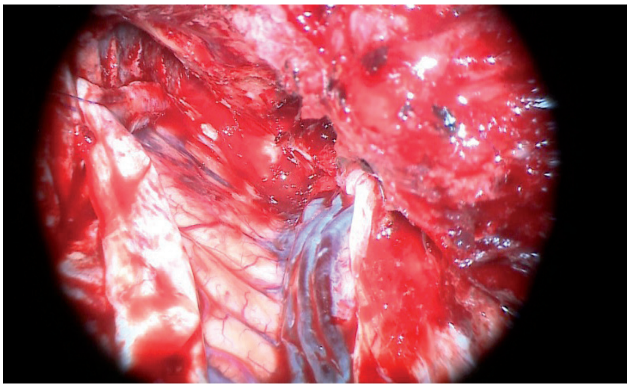

Image 9: Dural opening following the axis of the Sylvian valley.

The right Sylvian valley was opened until the right internal carotid artery is identified, with medial projection saccular aneurysm dependent on the supraclinoid portion. Carotid was occluded at the cervical level to obtain proximal control. The aneurysmatic dissection was completed and clipping was performed. Adequate clipping was verified intraoperatively using doppler and angiograph with green indocyanine *(→ Image 16)*. Careful hemostasis was performed, applying TachoSil® soaked with papaverine in the bed to prevent vasospasm. Bone reposition with screws, mini-plates and mesh. Both incisions were closed (cranial and cervical) using the conventional technique.

Evolution

After surgery the patient was admitted to the intensive care unit. Extubated without complications. The overall evolution was satisfactory, with hemodynamic and respiratory stability and without added neurological focality.

Due to the positive evolution he was transferred to the hospital floor. Without incidents with respect to the surgical wound. At 72 hours after the surgery right homonymous hemianopsia appeared. Assessed by ophthalmology which corroborates the finding and recommends follow-up. A cerebral CT with angio CT with adequate exclusion of the right aneurysm was carried out, without associated complications, the left aneurysm remained unchanged. The patient tolerated oral intake and walked independently around the unit. Due to the positive evolution it was decided to discharge the patient for continued recovery, waiting for the second surgery to treat the left internal carotid aneurysm.

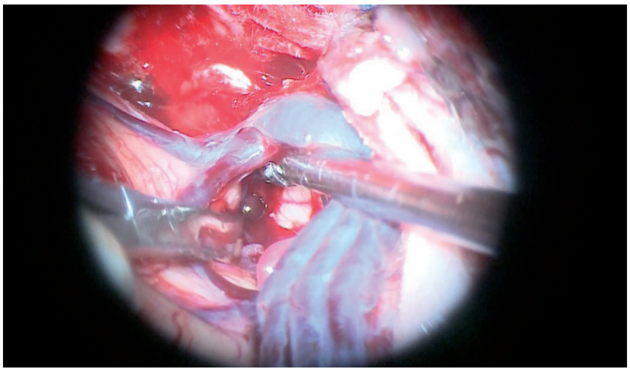

Image 10: Initiation of the opening of the Sylvian valley.

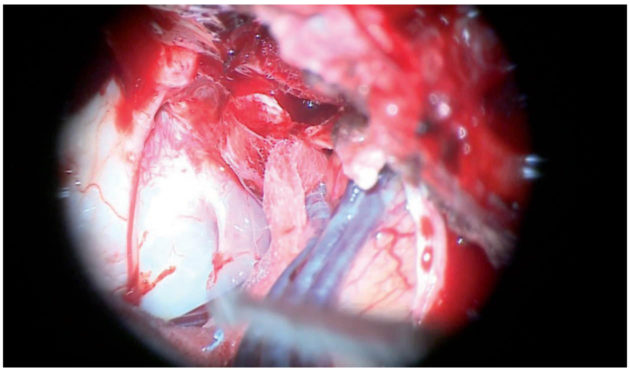

Image 11: After completing the dissection up to the proximal Sylvian valley, the right optic nerve and the right internal carotid artery are identified. A saccular structure, dependent on the right internal carotid artery is observed, compatible with aneurysm.

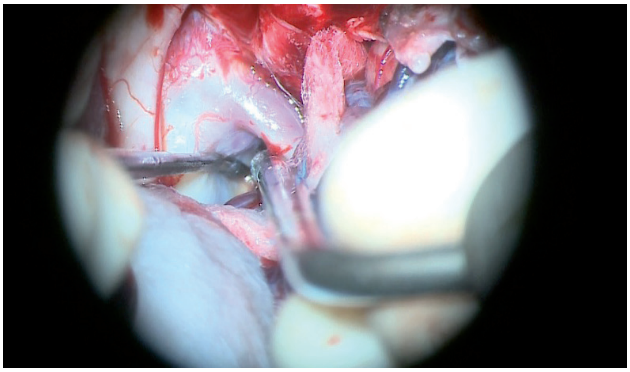

Image 12: Identification of the neck of the aneurysm.

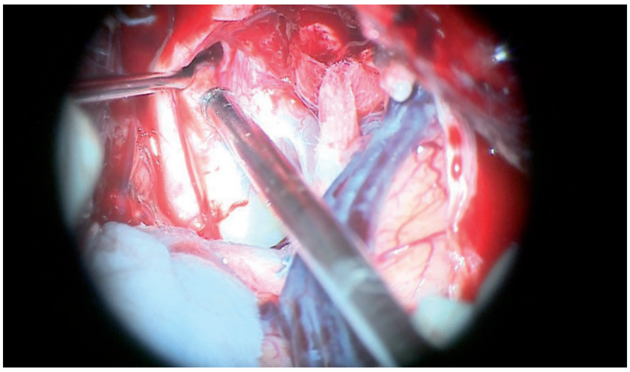

Image 13: Working on the dissection of the aneurysm from the rest of the adjacent structures and the identification of the neck.

Discussion

Cerebral vasospasm is a common complication after a subarachnoid hemorrhage (SAH) secondary to aneurysmatic rupture (2/3 of the patients[1,2]). The incidence of this complication is correlated with the quantity of blood in the subarachnoid space. Between 20 – 40 % of the patients with radiological vasospasm will present associated clinical symptoms (clinical vasospasm[2]).

However, vasospasm after elective clipping of an unruptured aneurysm is quite rare[3].

In cases of SAH the appearance of vasospasm is associated to the irritating effect of blood and its degraded products on the cerebral vessels[3,4]. However, in cases of elective surgery, there is no blood in the arachnoid space, therefore, other factors implicated in its pathogenesis must exist.

In cases of elective surgery for cerebral aneurysms the appearance of postsurgical vasospasm has un unknown physiopathology and is considered to be of multifactor ethology (brain damage, vascular damage, production of spasmogenic substances, failure of adequate response of the vascular wall, dehydration of the arteries exposed during surgery, among others[3]).

When this complication appears, due to ruptured aneurysms or elective surgeries, it is of vital importance to establish an early diagnosis and treatment. The treatment is based on the local application of vasodilators using therapeutic angiography (management quite similar to the vasospasm in ruptured aneurysms[1,3]).

In our center, after aneurysmatic clipping, both in cases of ruptured aneurysms as well as elective surgery, we routinely apply TachoSil® in small pieces soaked in papaverine *(→ Images 17 – 19)* We use this method of local application of a vasodilating substance, trying to minimize all of mechanisms that may cause vasospasm.

We consider that this practice reduces the incidence of vasospasm, without observing associated complications[5].

New studies are required to confirm the effectiveness of TachoSil® with papaverine for the prevention of vasospasm. It would also be of interest to compare the results of the application of papaverine with other vasodilating substances (such as calcium channel antagonists).

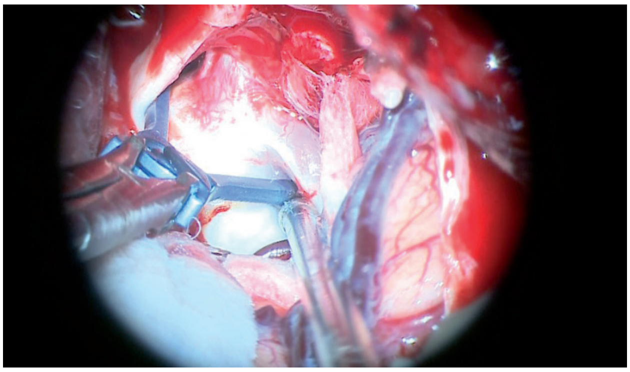

Image 14: Clipping attempt with standard Peter Lazic straight clip of 21 millimeters. The final maneuvers of the aneurysmatic dissection and exposition of the neck, as well as the clipping, is performed under cervical control with the assistance of the vascular surgery service.

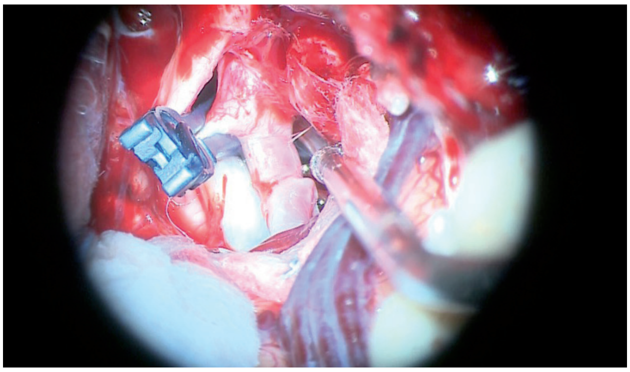

Image 15: Result of the clipping.

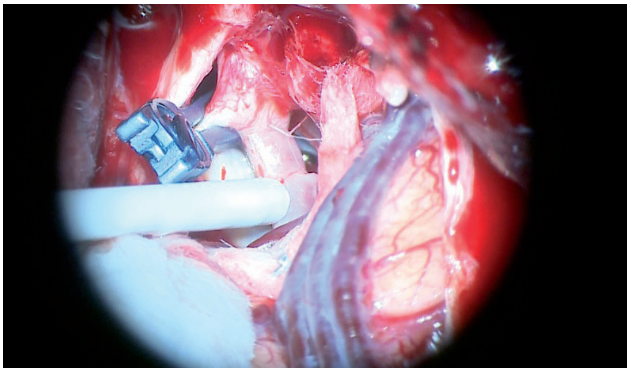

Image 16: Adequate clipping is verified intraoperatively using doppler and green indocyanine.

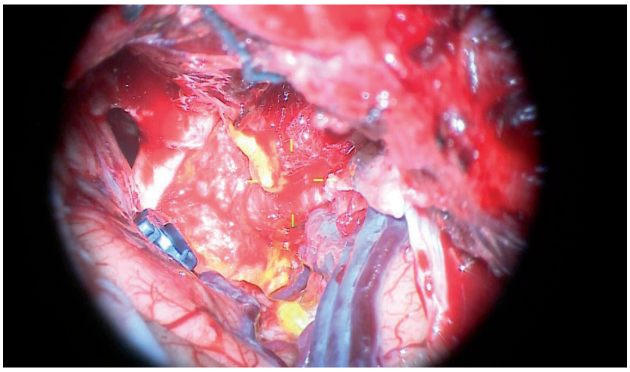

Image 17: Application of TachoSil® with papaverine in surgical bed for prevention of vasospasm.

On the other hand, this case also illustrates the surgical treatment of a paraclinoid aneurysm.
This type of aneurysm is the most technically difficult in anterior circulation aneurysm surgery, due to its relationship with the adjacent anatomical structures[6]. In some patients endovascular treatment can be considered, although this is associated with a lower rate of occlusion and greater probability of recurrence.

In such cases, it is necessary to control the carotid artery at the cervical level, both internally and externally, to obtain proximal control. It is necessary to perform an anterior clinoidectomy *(→ Image 8)* to have good access to the paraclinoid portion of the carotid In addition, it is necessary to open the distal dural ring to have adequate access to the neck of the aneurysm.

The visual complications are assumed to be the most frequent deficit in this surgery, as occurred in our case. The frequency of the appearance of this complication can reach 28.5 % of the cases in some series[6]. The mechanisms implicated in this deficit can include thermal lesion of the optic nerve during the opening of the optic canal, manipulation of the optic nerve during the maneuvers to dissect the aneurysm, ischemia of the optic path or direct compression by the clip.

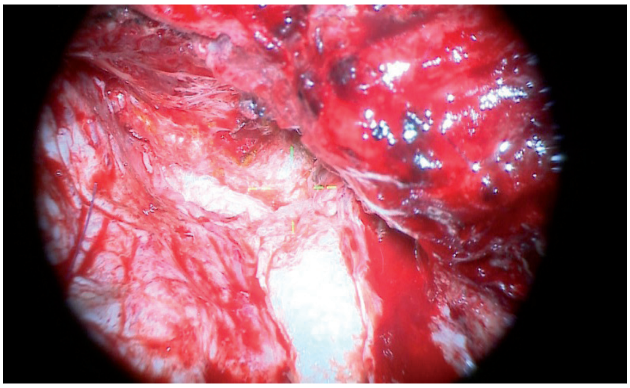

Image 18: Application of TachoSil® covering the reamed zone of the sphenoid wing and in subdural position to favor a hermetic dural closure.

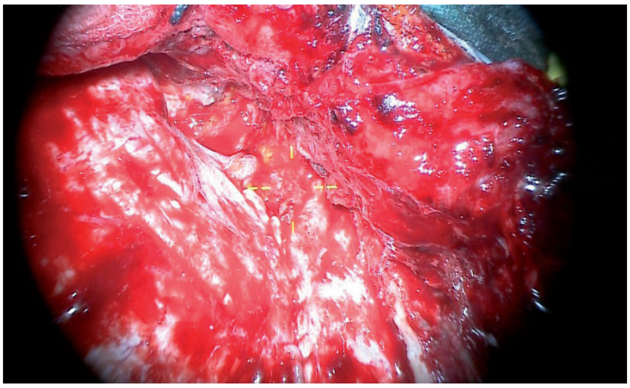

Image 19: Dural closure with absorbable monofilament. TachoSil® covering the reamed zone of the sphenoid wing.

Image 20: Postsurgical cerebral CT, showing changes in relation to the peritoneal craniotomy, reamed sphenoid wing and anterior clinoidectomy. View of right internal carotid artery aneurysm clipping in the paraclinoid portion. No significant complications are observed.

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Arachnoid cyst of the posterior fossa in the adult. Excision and fenestration with microsurgery and dural sealing with collagen enriched adhesive matrix with fibrinogen and thrombin

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Introduction

Arachnoid cysts (AC) are encapsulated collections of liquid identical to cerebrospinal fluid (CSF) that are produced during the development of the embryo. Two etiological theories exist: the formation of the cyst in the context of a dysgenesis of a cerebral lobe or due to a disorder in the formation of the arachnoid membranes in the fetal stage[1].

Their diagnosis is radiological using cerebral CT or MRI. They are more frequent in men with a distribution of 4:1 and they are fundamentally diagnosed in the pediatric age group. The most frequent location is the middle cranial fossa (50 %), generally on the left side followed by the posterior fossa (pontocerebellar angle (11 %), supracollicular region (10 %) or cerebellar vermis region (9 %)). Other less frequent locations include the rachimedullary region, the cranial base or the cerebral convexity[2].

The majority of the AC are small and asymptomatic; however, the large cysts or those with progressive growth can provoke neurological symptoms[3].

The treatment of the AC presents certain controversy. However, it is accepted that the cysts with progressive growth or symptomatic, tend to require surgical treatment. Among the surgical complications of the AC the CSF fistula stands out, above all, if it is located in the posterior cranial fossa or at the cranial base. In these cases, the surgical sealing of the dura mater must be exhaustive.

We present the case of a patient that has an extensive posterior fossa cyst that causes a type I Chiari deformation and secondary syringomyelia, which was treated with micro-surgical excision and dural sealing with an adhesive collagen matrix fortified with human fibrinogen and thrombin.

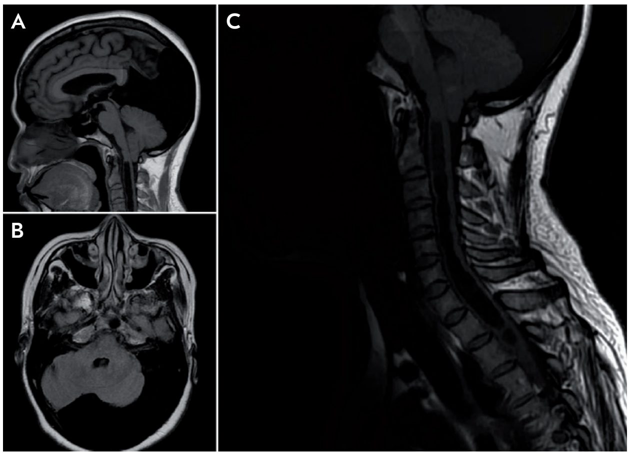

Image 1: Cranial MRI sequenced in T1. **A:** Sagittal slice that shows the extension of the supraretrocerebellar cyst in the cranial-caudal axis. **B:** Axial slice that shows the extension of the cyst on the lateral axis, the left predominance and the compression on the cerebellum. **C:** Sagittal slice of the cranial-cervical region that shows the type I Chiari deformation and the cervical-dorsal syringomyelia associated with the posterior fossa cyst.

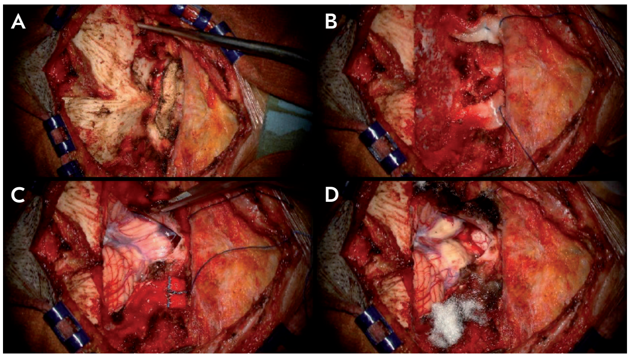

Image 2: Intraoperative images. **A:** View of the exposure of the occipital bone and the C1 posterior arch through a midline suboccipital approach. **B:** View of the exposure of the suboccipital craniectomy and excision of the C1 posterior arch. **C:** View of the durotomy and the excision of the membranes of the cyst and arachnoids adjacent to the magna cistern. **D:** View of the coagulation and retraction of the cerebellar tonsils up to the decompression of the underlying spinal cord.

Clinical case

Female of 45 years old, without medical history, with symptoms of pharmacoresistant headaches, sensation of vertigo and loss of strength and sensitivity in the upper right extremity of various months of evolution. The physical examination showed a reduction of strength in the right upper extremity with motor balance of 4/5, generalized dysesthesia in arm and right hand, generalized hyperreflexia and gait instability. The cranial MRI showed a posterior fossa AC at the retro cerebellar level that produced an amygdala descent of 11 mm below the McRae line in the context of type I Chiari deformation and secondary syringomyelia from C1 to T5 that covered the entire medullary thickness *(→ Image 1).*

The neurophysiological study showed involvement of the somatosesthesia at the level of the right extremities, especially in the right upper extremity suggestive of posterior chordal involvement at the cervical and brainstem level. Surgical treatment was performed by a suboccipital craniectomy and excision of the posterior arch of C1, durotomy, excision of the cystic wall and fenestration in the cranial-caudal axis, coagulation and retraction of the cerebellar tonsils and dural expansion with autologous pericranium *(→ Image 2).*

Faced with the possibility of a high debit liquor fistula, a dural sealant was performed with a collagen adhesive matrix fortified with human fibrinogen and thrombin of the TachoSil® type *(→ Image 3).*

In our case, we used an adhesive matrix of collagen fortified with human fibrinogen and thrombin of the TachoSil® type. During the process of its use we cut the matrix for covering the entire area of the craniectomy and we soaked it with a humid gauze for two minutes. After this process the matrix stayed firmly uniformly adhered to the tissue. The sealing was verified with a Valsalva maneuver and confirmed the complete seal of the dura mater.

After the surgery the patient evolved favorable, without CSF fistula or pseudomeningocele. One month after the surgery, the patient reported a substantial improvement of headache and motor deficit. The control CT showed persistence in the pseudocystic cavity, reduction of the herniation of the cerebellar tonsils with improvement of the compression on the spinal cord *(→ Image 4).*

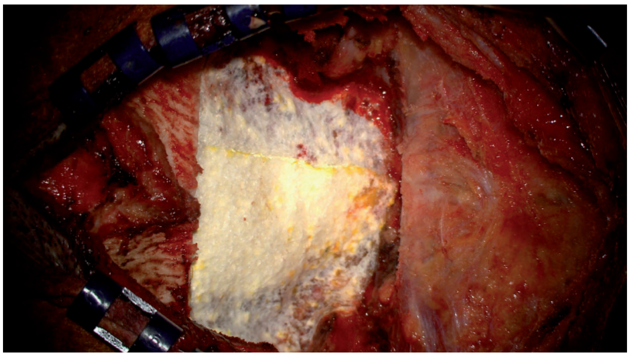

Image 3: Intraoperative image. View of the dura mater sealed with collagen enriched matrix with fibrinogen and thrombin (TachoSil®). Intra-operative verification of absence of fistula through the Valsalva maneuver.

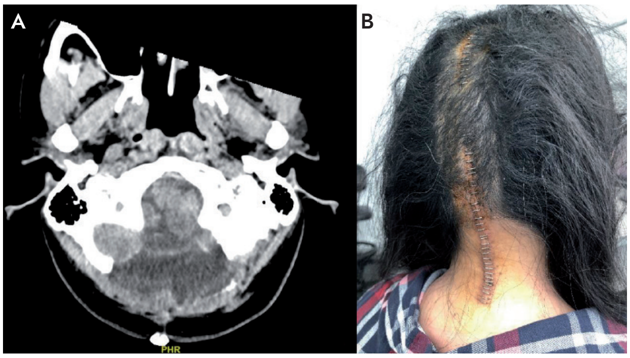

Image 4: A: Postoperative cranial CT that shows the absence of hemorrhages, fistulas or pseudomeningoceles after the treatment. The matrix covering the extension of the area without skull bone. **B:** Photo of the patient ten days after surgery. An adequate scar on the surgical wound is observed as well as the absence of subcutaneous collections or other signs suggestive of hemorrhage or postoperative cerebrospinal fluid fistula.

Discussion

The treatment of small or stable AC is conservative with a periodic clinical-radiological follow-up. On the other hand, the progressive AC or those that generate neurological symptoms tend to require surgical treatment. Several treatment methods exist: trepanation and aspiration of the cystic content, microsurgical excision of the cyst, fenestration of the cyst up to the intracranial cistern through endoscopic surgery or cysto-peritoneal/cisto-atrial shunt.

The most frequent treatment is the endoscopic fenestration of the cyst or the excision through open surgery, since, on the one hand it permits a direct view of the cyst and its relationships with the contiguous anatomical structures and on the other, it permits the excision or perforation of the partitions or loculations, which considerably reduces the risk of reoccurrence[4].

Nonetheless, cases have been described in which scarring and closure of the cysto-cisternal fenestration is occurs, causing a reproduction of the cyst. In spite of this, the trend continues to be use of endoscopic surgery as the first option and open surgery in case of relapse of failure of the fenestration, before implanting a permanent derivation. In the cysts located in the posterior fossa, open surgery through microsurgical excision of the walls of the cyst and the fenestration up to the magna cistern tend to be the technique of choice. The dural opening must be wide with the objective of viewing, if possible, the limits of the cyst and performing a safe microsurgical dissection.

On the other hand, the dural plasty must be sufficiently ample to avoid a commitment of space in an iatrogenic way. In the majority of cases autologous pericranium grafts tend to be used or synthetic plasties of the dura mater. In our case, an autologous pericranium graft was used taking advantage of the same cutaneous incision. Surgery of the posterior fossa implies an elevated risk of CSF fistula, and concretely, the AC excision surgery carries an added risk, since high debit fistulas may exist as a consequence of the perforation of the arachnoid membranes and the recirculation of liquid through the cavity that is formed. For this reason, the closure and dural sealing must be meticulous. Many materials exist that help to perform hemostasis and sealing of the dura mater.

Currently, the most employed in surgical practice are the collagen matrixes, which favor the migration and proliferation of fibroblasts around the matrix, which is reabsorbed as time passes[5].

TachoSil® is a collagen matrix coated with human fibrinogen and thrombin, that has been used efficient ly and safely in neurosurgical procedures. In the literature it has been reported that up to 96 % of the patients treated with TachoSil® as a hemostatic agent and sealant do not present complications related to perioperative hemorrhage, CSF leaks or complicated infections[6].

In the CA surgery of the posterior fossa the TachoSil® can obtain low CSF leak rates in comparison with other sealing agents[7], reason for which its use is increasingly extended.

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21

Use of TachoSil® to seal the ventricular defect and intraoperative radiotherapy (IORT) after excision of a cerebral metastasis

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Introduction

Cerebral metastasis is associated with poor prognosis in patients with cancer. During the course of the illness, between 15 – 30 % of the patients are diagnosed with cerebral metastasis. This diagnosis is increasing due to the improved resolution of imaging techniques and the increase in the survival time of the patients[1].

The principal objectives of treatment of cerebral metastasis are to control the local illness and provide a satisfactory quality of life[1,2].

It has been suggested that, in single brain metastasis of more than 3 cm in size, the first therapeutic option consists of surgical excision followed by adjuvant radiotherapy[2].

The use of intraoperative radiotherapy (IORT) presents potential advantages compared to external postoperative radiotherapy.[3] The usefulness of this treatment is being evaluated in our center under a clinical trial. The use of TachoSil® in the clinical case that we will presented has permitted the surgical bed to unite the appropriate conditions for the application of IORT. Without the use of TachoSil®, this treatment would not have been possible.

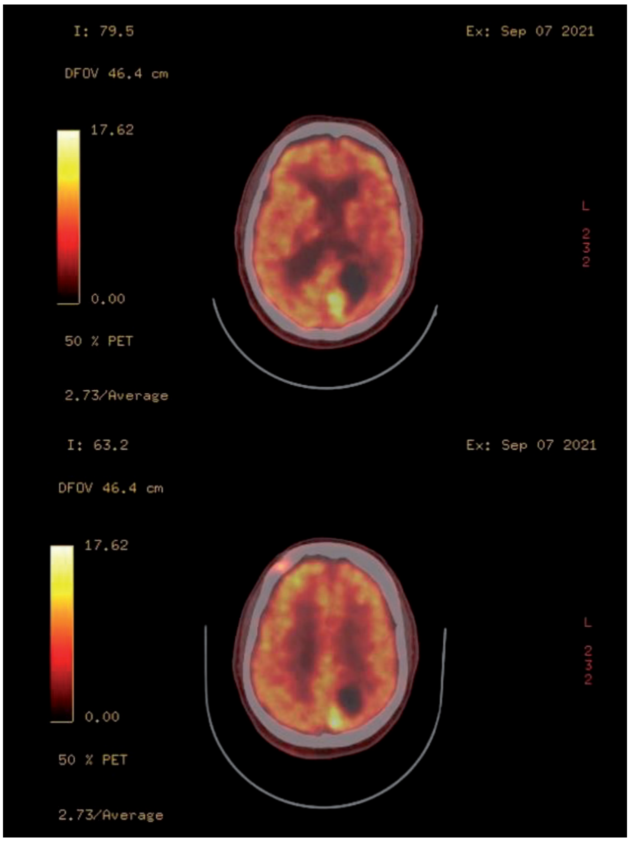

Image 1: PET/CT in September 2021 with occipital parasagittal nodular lesion, 25 x 17 mm, suggestive of cerebral metastasis.

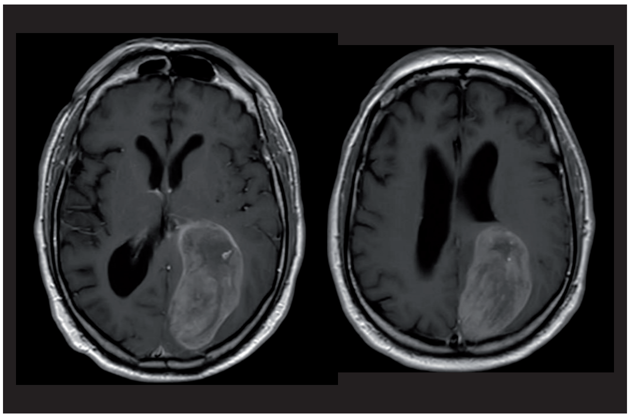

Image 2: Cerebral magnetic resonance imaging (axial slices in T1 sequence with Gadolinium) in October 2021, that describe an expansive intraparenchymal solid-necrotic expansive lesion at the left parieto-occipital level of 74 x 42 x 63 mm (CC x TR x AP).

Clinical case

Male of 78 years of age, without known allergies to medications, ex-smoker for 20 years, and with history of arterial hypertension, diabetes mellitus II, and dyslipidemia. Diagnosed in March 2020 of malignant cutaneous melanoma with superficial extension E-IIID in the right auricle the requires local resection, cervical lymphadenectomy, right superficial parotidectomy and an adjuvant therapy with Dabrafenib-Trametinib for one year.

In control visits, in the PET/TC of September 2021 evidence of a new left occipital-parietal cerebral lesion appeared, suggestive of metastasis *(→ Image 1)*. The patient presented right hemianopsia, minor compression dysphasia, alteration of fine motricity of the right hand and required a cane to walk, receiving a score on the Karnofsky (KPS) scale of 70. A cerebral MRI was carried out *(→ Image 2)* that confirmed the findings seen in the PEC/TC. In accordance with the decision our neuro-oncology committee of our center it was decided to intervene to resect the tumor and include in the clinical trial for the application of IORT.

The tumor excision was performed through a left parietal-occipital craniotomy. During the intervention, samples were sent for intraoperative analysis to confirm the diagnosis of metastasis so the patient was considered a candidate for IORT treatment. During the tumor resection, a necessary opening in the occipital ventricular horn was made that was sealed with TachoSil® *(→ Image 3)*, obtaining in this way a dry surgical bed suitable for the application of IORT. After obtaining a complete macroscopic resection of the lesion, 15.4 Gy was administered at 2 mm depth with 45 mm applicator (Zeiss® Intrabeam system) during 39 minutes. The procedure transpired without incidents.

In the immediate postoperative period, the patient presented mild worsening of motor dysphasia, which he progressively began to recover. A cerebral MRI was carried out *(→ Image 4)* at 72 hours after the surgery that informed the absence of findings suggestive of tumor remains.

The patient was discharged to his home the sixth day after the surgical intervention.

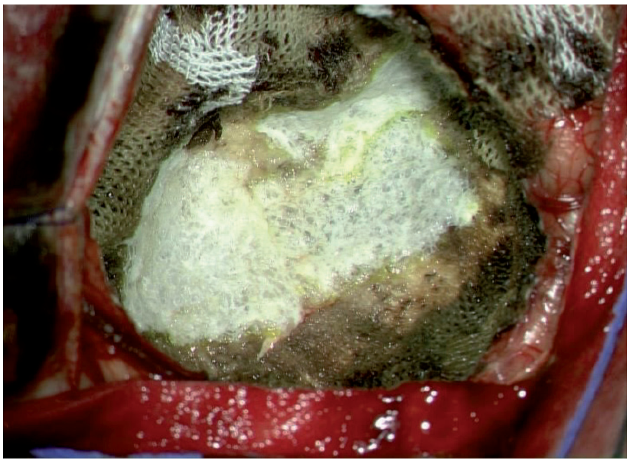

Image 3: During the tumor resection, a ventricular defect is created that is closed with TachoSil® to create a dry surgical bed suitable for IORT.

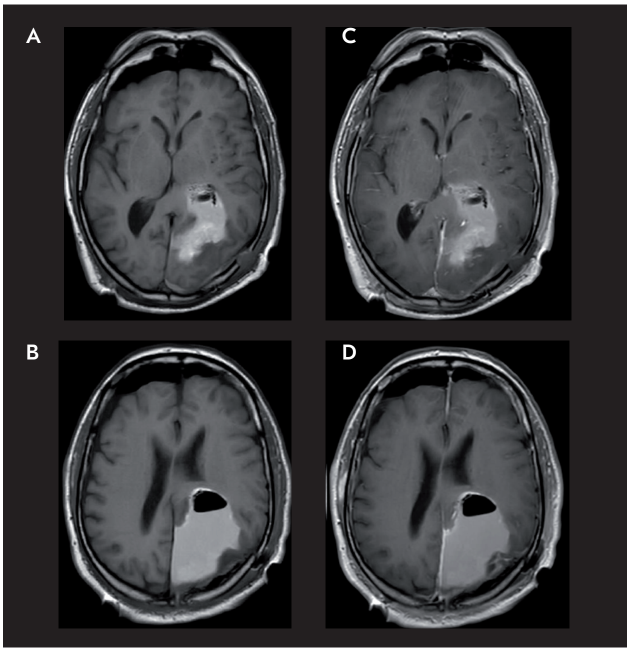

Image 4: Cerebral magnetic resonance 72 hours after the intervention without evidence of nodular enhancement suggestive of tumor remains. **A and C:** Axial slices T1 sequence without contrast and **B and D:** After the administration of gadolinium

Discussion

IORT consists in the administration of radiotherapy to the tumor bed during the same procedure as the surgery. Thanks to IORT it is possible to apply high dosages of radiation over the target tissue with minimal irradiation of the healthy surrounding tissue. The pioneers of this technique were Abe y col. of the University of Kyoto, Japan, in the 1960s, consolidating its use in intraabdominal tumors. Over the years, IORT has demonstrated its efficiency in different anatomical zones[3].

In addition to the optimization of the dosage of the radiation over the target tissue, the IORT reduces the time to start the treatment over the primary tumor in the case that the patient needs it, since the complete treatment of the cerebral illness is performed in the same procedure[4].

With the objective of demonstrating the effectivity of IORT, in the Hospital Universitario de Bellvitge ICO L´Hospitalet de Llobregat a prospective study has been designed for patients $>$ 18 years of age with resectable cerebral metastasis and KPS $\geq$ 70. It is a phase II clinical study, with encouraging partial results with respect to the tolerance of the applied treatment and local control of the illness.

For the application of IORT in cerebral metastasis there are some necessary requirements: complete tumor resection, adequate coaptation of the IORT applicator to the tumor bed and reduction in the highest possible degree of the existing barriers between the wall of the bed and the applicator[4,5]. In our case, the surgical filling with cerebrospinal fluid due to the ventricular opening is considered a contraindication for the application of IORT, since it requires that the surgical bed is dry so the effectiveness of the treatment is appropriate and the dosage over the tumor bed is homogeneous. TachoSil®, due to its hemostatic and sealing properties has provided a dry field suitable for the performance of the procedure.

Conclusion

Presented an illustrative case in which the application of TachoSil® has permitted the effective sealing of a ventricular defect and the use of IORT. Without the use of TachoSil®, the administration of this treatment would not have been possible.

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22 Strongyloides stercoralis hyper-infection syndrome after endoscopic resection of sphenoid meningioma

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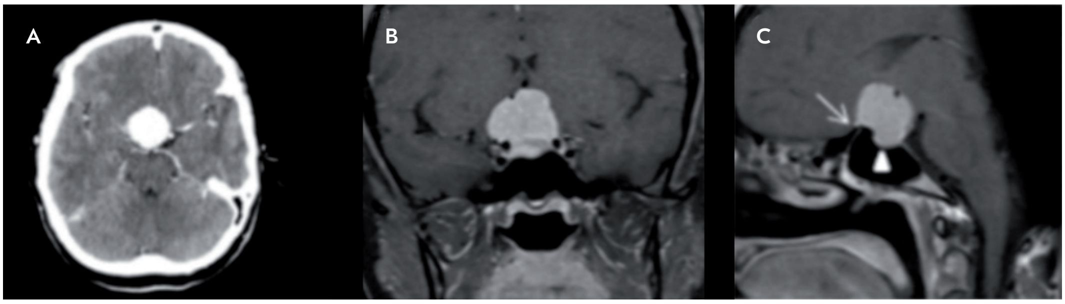

Image 1: Expansive suprasellar lesion that respects the hypophysis (arrow head) and presents dural tail (arrow) compatible with sphenoidal planum meningioma as a first possibility. **A:** Cranial CT with contrast, axial slice. **B and C:** MRI with contrast enhancing T1 sequence, coronal and sagittal slice, respectively.

Introduction

Strongyloidiasis is a disease caused by the helminth Strongyloides Stercoralis.
This microorganism is capable of completing its life cycle inside the human body as its host. In this way, chronic infection (asymptomatic in almost 100 % of the cases) can remain hidden for decades producing a reactivation of the infection in cases of immunosuppression (for example, after the establishment of treatment with corticosteroids)[1,2]. It is estimated that there is a global prevalence of chronic strongyloidiasis of 8.1 %, which corresponds to 614 million people worldwide, being endemic in Southeast Asia, Sub-Sarahan Africa and Latin America[2,3].

The principal cause of immunosuppression in neurosurgery is the use of corticosteroids for during long periods of time to reduce the cerebral or spinal edema associated with different pathologies considering it the principal risk factor of strongyloidiasis in the neurosurgical population. This is why it is very important in habitual neurosurgical practice the knowledge of the risk factors, as well as their diagnostic-therapeutic management, to avoid delays in its diagnosis, as it leads to an elevated morbimortality[4,5].

We present the case of Strongyloides Hyperinfectation Syndrome in a patient who underwent surgical intervention for a sphenoidal planum meningioma and was treated with corticosteroids perioperatively.

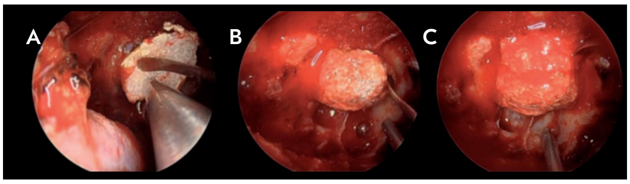

Image 2: Intraoperative implantation of the adhesive matrix (TachoSil®) through endoscopic view via transsphenoidal nasal route. Observation of three phases: **A:** Approaching the field. **B:** Placement in the definitive position. **C:** Change of color of the matrix when mixed with the blood and formation of the definitive fibrin plug.

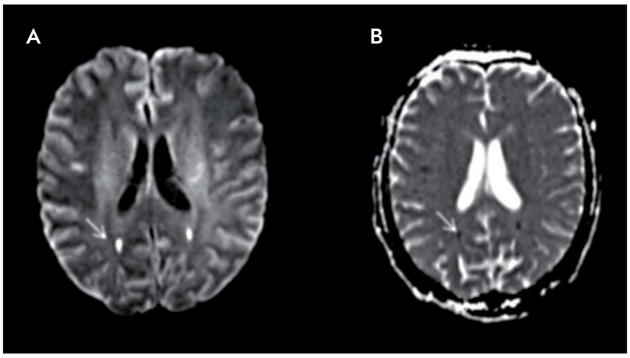

Image 3: Urgent cranial MRI without contrast, diffusion sequence. Multiple bilateral millimetric foci of diffusion restriction in the white matter, compatible with areas of ischemia. **A:** Sequence DWI (b = 1000). **B:** ADC Map.

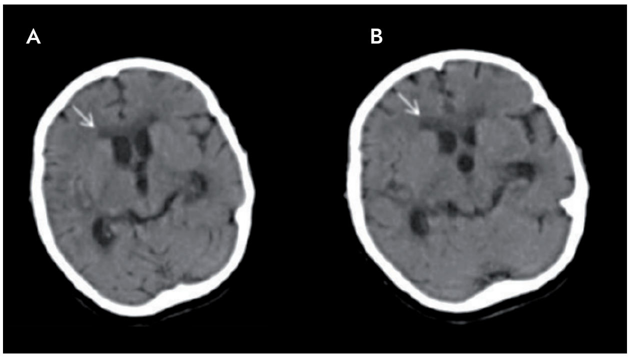

Image 4: Urgent cranial CT without contrast. A marked dilation of the ventricular system is observed with transependymal edema (arrow), compatible with communicating hydrocephalus. **A, B:** Axial sequence.

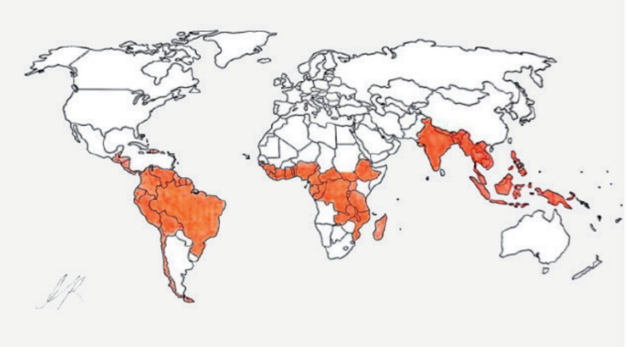

Image 5: Areas of major prevalence of Strongyloides Stercoralis Southeast Asia, Sub-Saharan Africa and Latin America.

Clinical case

Female patient of 33 years of age of Paraguayan nationality, resident in Spain for the last 15 years. She came as an emergency case with symptoms of headache with nausea and associated vomiting, as well as visual alterations. She presented bitemporal hemianopsia on campimetry. A cranial CT and MRI with contrast were performed, where a suprasellar mass of 3 cm could be seen that compressed the optic chiasm, compatible with sphenoidal planum as a first possibility *(→ Image 1)*. Treatment began with corticosteroids (Dexamethasone 4 mg every 8 hours) with a descending plan.

The surgical intervention through a transsphenoidal endoscopic approach extended to the sphenoidal planum, obtaining a total resection of the lesion. In the closure, due to the elevated risk of cerebrospinal fluid (CSF) fistula that these type of approaches present, it was key to employ the adhesive matrix of human fibrinogen and human thrombin (TachoSil®) *(→ Image 2)*, that when it comes in contact with the blood or CSF formed a fibrin plug that prevented the development of a possible fistula. The pathological anatomy was compatible with grade 1 meningioma (WHO 2021).

The initial postoperative period was uneventful, so the patient was discharged with a descending plan of corticosteroids (Dexamethasone) and a total duration of 21 days since the diagnosis.

Two weeks after the surgery, newly presentation due to symptoms of fever, dyspnea, cough with expectoration, and abdominal pain with bilious vomiting. On examinations, presented with bilateral pulmonary wheezing and serpiginous skin rash. Admitted to the hospital under the diagnosis of respiratory sepsis and antibiotic treatment was initiated.

On the 7th day of admittance, she started to have symptoms of holocranial headache, loss of bilateral vision and "shot gun" vomiting. Faced with suspicion of a possible pituitary apoplexy, an urgent cranial MRI without contrast was performed, where multiple diffusion restriction foci were observed, compatible with areas of ischemia *(→ Image 3)*.

Cultures of CSF were obtained where turbidity, hyperproteinorrachia, of 105 mg/dL (10 — 45), hypoglycorrhachia of 30 mg/dL (50 — 75) and marked increase of PMN to 1,500 (0 — 5) are reported. These findings were compatible with bacterial meningitis (positive gram-bacillus cultures). Given the situation the patient was admitted to the Intensive Care Unit (ICU).

At 24 hours presented a deterioration of the level of consciousness with Glasgow <8 and needs orotracheal intubation and mechanical ventilation. A cranial CT was performed which showed a marked dilation of the ventricular system, compatible with hydrocephalus secondary to the meningitis caused by gram bacilli *(→ Image 4)*. For this an external ventricular drain was implanted in the right Kocher point.

The blood tests were positive for Strongyloides Stercoralis (IgG+), as well as in the feces and sputum cultures, being diagnosed with Strongyloides Hyperinfection Syndrome. So a treatment was initiated with Ivermectin 200 mcg/kg/day.

Initially an adequate response to the treatment was seen with negativitization of the cultures. From the neurological point of view the improvement was not observed, remaining at all time in a vegetative state. Two months later, the patient died by multiple organ failure.

Discussion

The primary infection of Strongyloides Stercoralis is frequently caused by contact of bare feet on the ground in endemic regions (Southeast Asia, Sub-Saharan Africa and Latin America), constituting a risk both for residents as well as travelers in these areas *(→ Image 5)*. Therefore, it is very important to ask about the place of origin and recent travels prior to initiating treatment with corticosteroids (most frequent cause of immunosuppression in the neurosurgical population)[1,2,3]. In patients with chronic infection in which immunosuppression is induced, Strongyloides Hyperinfection Syndrome can be developed, which is consistent with accelerated autoinfection that affects the skin respiratory and digestive tract[4,5].

Likewise, it favors the translocation of gram-negative bacteria, which can produce fatal illnesses (sepsis, meningitis, pneumonia...) with a mortality rate of 70 — 100 %[4,5].

In the case of our patient, due to the iatrogenic immunosuppression due to corticosteroids the typical hyperinfection syndrome occurs, with secondary gram-negative meningitis and associated hydrocephalus, leading to multiple organ failure and death.

To establish an adequate diagnosis, it is important to have an elevated suspicion before patients from the endemic regions that present compatible symptomology. Serological tests are used (ELISA), with an elevated sensitivity and specificity[6,7].

From the therapeutic point of view, the anthelmintic chemotherapy is indicated both in symptomatic as well as asymptomatic patients, with the objective of curing the infection[8,9].

This is especially important in those patients that are going to be subjected to immunosuppressant treatment, since the infection must be eradicated before beginning it. Ivermectin 200 mcg/kg/day during two weeks[8,9,10].

Conclusion

The use of corticosteroids is the most frequent cause of hyperinfection in patients with undiagnosed chronic strongyloidiasis. This is especially relevant in the neurosurgical population.

Having an initial suspicion is very important, since in the absence of an early diagnosis and treatment, the prognosis of disseminated strongyloidiasis is fateful (mortality rate of 70 – 100 %).

It could be interesting to discard a previous chronic infection for Strongyloids in patients coming from risk areas (immigrants or recent travelers from Southeast Asia, Sub-Saharan Africa or Latin America) before initiating the treatment with corticosteroids. To do so, serology (ELISA) could be used before initiating the corticosteroids and establishing the treatment with Ivermectin 200 mcg/kg/day when it is positive.

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Tentorial meningioma with complete invasion of the transverse sinus

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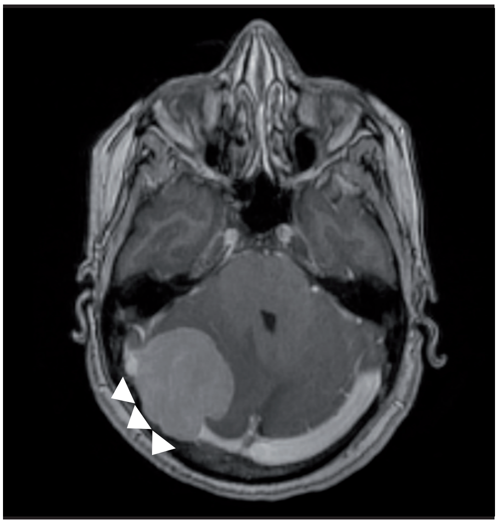

Image 1: Axial view of MRI weighted in T1 with gadolinium, where a solid extraaxial lesion can be observed in the right hemicerebellar (with intense and homogeneous enhancement due to contrast) compatible with meningioma of the posterior fossa with invasion of the transverse sinus. The white arrows indicate where the sigmoid sinus should be located.

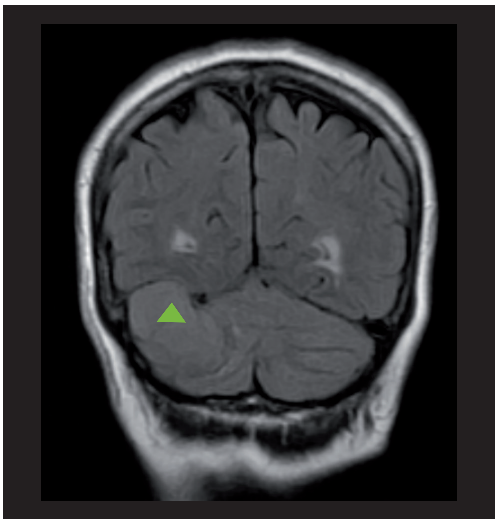

Image 2: Coronal view of the MRI FLAIR of the right hemicerebellar lesion (without gadolinium) dependent on the tentorium and with elevation of the same. The green arrow shows us the invasion and elevation of the transverse sinus due to the lesion.

Introduction

In this presentation the objective is to explain the different uses of TachoSil® in the same clinical case, both its hemostatic effect in a profuse hemorrhage of the transverse sinus vein after the removal of an infiltrating meningioma, as well as its effect as a sealant of the dura mater with a deficit in the approximation.

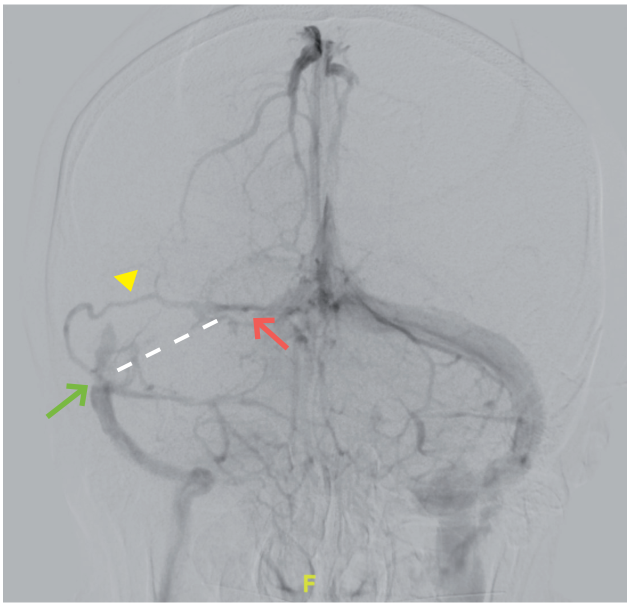

Image 3: Arteriography where we can observe the lack of venous circulation in the right transverse sinus enclosed in the tumor. It presents flow in its proximal and distal parts (confluence with the sigmoid sinus) due to collateral circulation vein. The red arrow indicates the portion close to the right transverse sinus, still patent. The broken white line indicates where the sigmoid sinus should be located. The yellow triangle highlights the collateral circulation vein replacing the part of the obstructed sinus. The green arrow indicates the right sigmoid sinus.

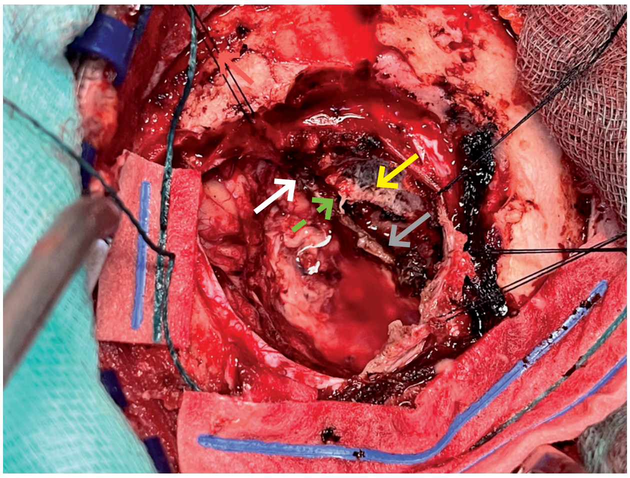

Image 4: In this image, after the tumor dissection and of both extreme sides of the transverse sinus, profuse venous bleeding occurs from both patent venous sinuses that is easily controlled thanks to hemostatic sealing and with TachoSil®. The yellow arrow corresponds to the TachoSil® seal of the proximal transverse sinus. The broken green line is the empty transvers sinus.
The white arrow points to the sell of the distal part of the transverse sinus in its union with the sigmoid sinus. The grey arrow indicates the cut tentorium (location of the implantation of the lesion) and after it, the retracted cerebellar after the excision of the lesion.

Clinical case

Patient of 53 years of age, without history, with symptoms of intense headaches difficult to control with analgesics (without any added neurological focality), and an extraaxial solid lesion of 46 x 32 x 43 mm is found in the right hemicerebellar, dependent on the tentorium and compatible with posterior fossa meningioma with invasion of the transverse sinus *(→ Images 1 and 2).*

An arteriography was performed where absence of venous circulation was observed in the right transverse sinus encompassed by the tumor *(→ Image 3),* with flow in its proximal and distal parts (confluence with the sigmoid sinus) due to collateral circulation vein.

We proceeded to the embolization with 250 mc particles and coils up to the pedicle and branches of the tumor dependent on the occipital artery, the complete occlusion of the right transverse sinus is confirmed in the area encompassed by the tumor lesion.

After 48 hours of the embolization, and without secondary complications of the same, a programmed surgical intervention is performed using a paramedian suboccipital approach.

Resection of the lesion (compatible with meningioma) by debulking, dissection of the adjacent cerebellar parenchyma and disinsertion of its implantation base in the tentorium. Finally, from an interior perspective, the transverse sinus encompassed by the tumor is emptied (Sindou V classification: without involvement of the contralateral sinus wall). In the tumor dissection of both sides of the intrasinus tumor (union with the proximal transverse sinus and the sigmoid sinus at the distal level) profuse venous bleeding occurs from both patent venous sinuses that is easily controlled with hemostatic sealing through the application of TachoSil® *(→ Image 4).*

Once the hemostasis and the complete excision of the lesion were performed we proceeded to closure. Dural plasty is performed with Duraguard (since the infiltrated dura mater is completely removed) sutured using simple non-hermetic stitches and then sealed with TachoSil® *(→ Image 5).*

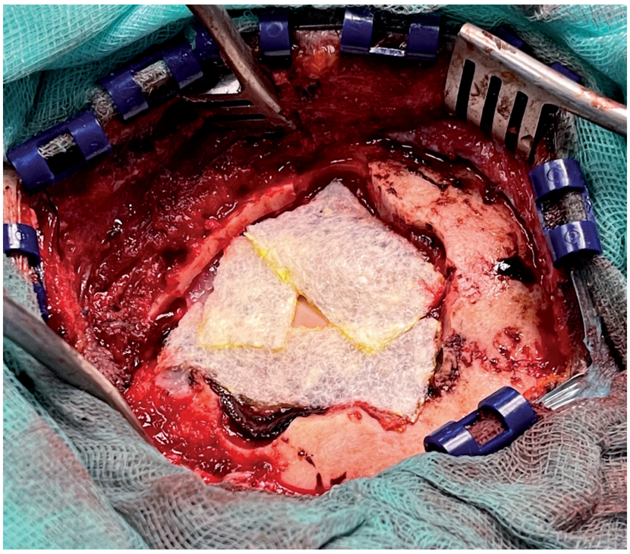

Image 5: This image shows the dural sealing with TachoSil® after non-hermetic dural plasty performed with suture.

The patient had postoperative no incidents of hemorrhage (absence of sinus bleeding) and is discharged without CSF fistula at five days of the intervention.

Discussion

It can be deduced that this clinical case of the use of TachoSil® is a great support mechanism in the control of high-flow venous bleeding, with an important reduction of the time of hemostatic control[1] as well as the absence of complications resulting from the same. In addition, it provides an efficient seal[2] of an incomplete closure of the dura mater, with complete absence of CSF fistula and therefore, favoring early hospital discharge.

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24

Use of TachoSil® for the ventricular seal

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Introduction

In neurosurgery the interventions that require entry into the ventricle are historically associated with a high level of perioperative complications. Half of these patients develop a complication as a consequence of the ventricular inlet[6]. In the following we describe some of these complications and the risks that these imply for the patient:

CSF fistula

Postoperative CSF fistula is a frequent complication in skull base surgery and in neuro-surgery in general. In the literature a great variability of the definition of CSF fistula exists[8]. It may manifest as rhinolicuorrhea, otolicuorrhea, or fluid leakage through the surgical wound (incisional leakage). It is diagnosed clinically or using the Beta-2-transferrin test in cases where there is a doubt.

This complication can lead to secondary complications such as infection of the wound, meningitis, dehiscence of the wound, or licuoral hypotension. In supratentorial surgery the range of incidence is of 1.2 % to 10.9 % with a median of 4.9 %[3]. There exists a wide range of the incidence due to the different types of surgery (posterior fossa surgery, epilepsy surgery...)[8].

Factors exist that increase their risk up to 15 % or 20 % such as[4]:

- If the surgery is located in the posterior fossa of the cranial base of the spinal level
- If the patient has had previous surgeries in the same location
- If postsurgical hydrocephalus appears
- If radiotherapy has been applied to the intervened area or in its proximity
- If there has been prior treatment with chemotherapy
- Presence of factors associated with the patient such as diabetes, malnutrition...
- If the ventricle is opened during surgery[2]

To prevent CSF fistula a meticulous closure must be performed to obtain maximum impermeability. This factor may require the use of a dural implant (of any kind) and/or a dural sealant[1].

The consequences for the patient of the appearance of CSF fistula, can be serious and important. It implies a considerable increase in their hospital stay, a risk of reintervention, the risk of morbidity and mortality as well as an increased risk of infections. All of this leads to an important increase in the economic costs during the entire process[10].

A pair of studies exist where the difference in the cost of the patients with postoperative fistula is compared to that of patients without fistula. The difference surpasses 17,000 €[10].

The postoperative CSF fistula can be treated conservatively (bed rest or compressive bandages), review of the surgical wound at a superficial level (which in many cases is ineffective), deep surgical review, lumbar puncture or placement of a temporary or definitive CSF shunting system[3,10].

There exists a wide range of the incidence due to the different types of surgery (posterior fossa surgery, epilepsy surgery...). Many analyses also fail to differentiate risk factors such as age, patient's immune status, previous radiotherapy or chemotherapy, use of postoperative drainage, postoperative hydrocephalus, ventricular opening or use of sealants[8].

Hydrocephalus

Defined as the accumulation of an excessive amount of CSF on the brain. This accumulation can cause damage on the brain.

The mechanism for the development of hydrocephalus during open ventricular surgery can be multifactorial. It is believed that an increase in the precipitation of proteins (due to the presence of tumor cells or of the surgical detritus in the CSF) hinder CSF reabsorption capacity in the arachnoid granules with the consequent appearance of hydrocephalus[7].

Its treatment requires the placement of a transitory or definitive CSF shunt system.

According to a meta-analysis of a pediatric population that reports the treatment of CSF fistula, 31 of 114 patients had a ventriculoperitoneal shunt (32 %)[8].

Pseudomeningocele

Pseudomeningocele is an abnormal collection of CSF in the epidural space and/or in the pericranial soft tissue. Its incidence after cranial surgery has a range from 4.3 % to 28 %[9].

Diverse theories exist to explain its pathophysiopathology but none has been proven. The factors that are associated are the tearing of underlying tissue, infection, previous radiotherapy, elevated CSF pressure that can contribute to the formation, and failure in the resolution of the pseudomeningocele[9].

It is believed that the risk of its appearance can increase if the patient presents important efforts during the postoperative period due to nauseas or poor bed rest, if it is a surgery in the posterior fossa or due to the opening of the ventricle.

It has been implied in some articles that the replacement of the bone flap diminishes the continuous increases, and declines of the dural stress caused by the triphasic pulses of the CSF. The bone flap reduces the space created between the muscle plane and the dura mater limiting the creation of a possible pseudomeningocele[8]. The pseudomeningocele can appear as practically asymptomatic, to clinical intracranial hypotension, aseptic meningitis, pain and psychological distress. The description of the pseudomeningocele and its quantification can be difficult since many times the diagnosis can be more suggestive in contrast to the incisional CSF fistula. For this motive it is considered a separate entity[8].

Frequently it appears a few days after surgery and although it appears almost immediately, intracranial hypertension or valvular dysfunction should be suspected as the most common causes.

The management of iatrogenic pseudomeningocele is a problematic question with great variability. Its largest part (almost three quarter parts) are auto limited in the first weeks, for which a surgical revision is initially contraindicated. In the cases where conservative treatment fails, the possibility of a surgical review of the would should be assessed, or the placement of a temporary or permanent CSF shunt.

Meningitis

The incidence of postsurgical meningitis is of approximately 0.3 to 8.6 %[5]. This complication as well as the others, leads to an increase in the morbidity and mortality, the hospital stay and hospital expenses.

Its ethology can be septic (habitually caused by cutaneous germs or by gram-negative bacillus) or inflammatory caused by the degradation of the hematic remains in the surgical bed or by an idiosyncratic reaction to the dura plasties and/or dural sealants used during surgery[5].

In the cases of septic meningitis, the factors that are related to its appearance are:

- Infection in another part of the body (be it pneumonia, urinary tract...)
- Duration of the intervention (more than four hours)
- Number of interventions (more than one)
- Being a carrier of a CSF drainage shunt
- ASA score superior to 2

The risk of infection is not related to the type of material implanted or with the placement of a foreign body during surgery (skull fixator, dural implants, sealants...)[5]. For its postoperative management the differential diagnosis between septic or aseptic conditions is indispensable since the treatment may be antibiotics or antinflammatories.

The postsurgical meningitis increases the risk of requiring a definitive CSF shunt valve in the future.

The dural plasties and sealants of animal origin increase the risk of aseptic meningitis as opposed to those of human origin which decrease the risk.

Many products are available for dural reconstruction after skull surgery (with or without ventricular opening). Many of these can be combined among themselves of used with different products to reinforce the closure. All of the products that exist in the system are for use at the epidural level.

Clinical case

We now present a series of ten cases of interventions all due to a tumor pathology in the periventricular location and that during surgery required ventricular opening for tumor resection.

We present a brief summary of the case with the preoperative images and the posterior controls with cranial MRIs. The first case is presented in the most complete form with intraoperative photographs of the ventricular opening and the posterior placement of TachoSil® for the sealing of the ventricle.

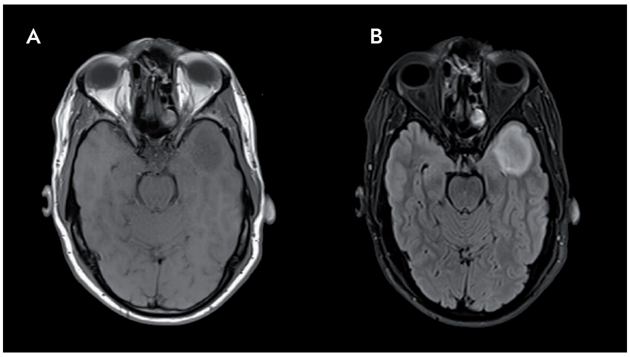

Image 1: A and B: Presurgical MRI 10-25-21. An infiltrating tumor suggestive of low-grade glioma is visualized in contact with the left temporal ventricle.

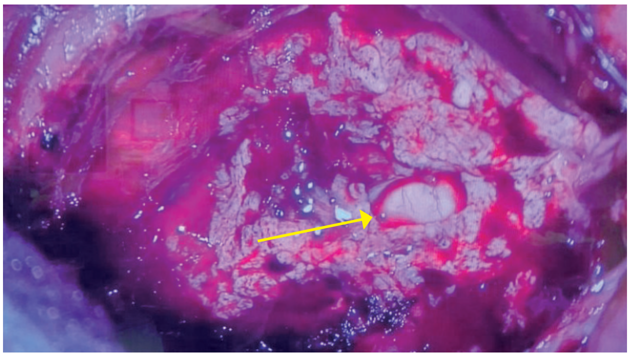

Image 2A: Opening up to the temporal of the left lateral ventricle. Indicated with a yellow arrow.

1st Clinical case:

- Male patient of 38 years old.
- **CH:** smoker.
- **Initial clinical:** partial motor crisis.
- Is diagnosed with left temporal infiltrative lesion suggestive of low grade glioma.
- **IQ 11-25-21:** Temporal ventricle opening with placement of ventricular sealant with TachoSil®.
- Complete resection of the tumor lesion.
- **CH:** Astrocytoma, mutated HDI, grade 2 malignancy.
- The patient has an immediate favorable postoperative outcome without complications.

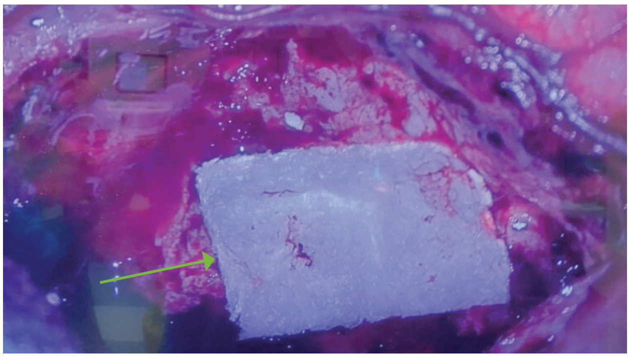

Image 2B: Piece of TachoSil® for the ventricular seal. Indicated with a green arrow.

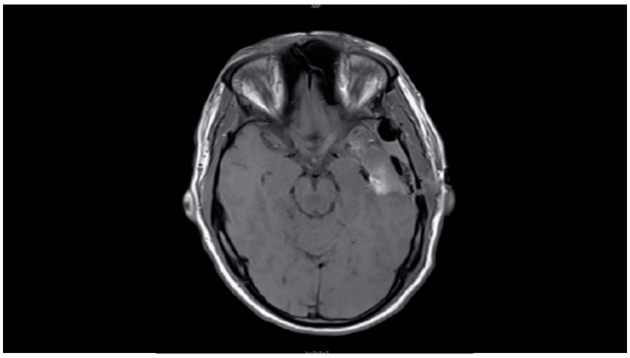

Image 4: Cranial MRI at two months postsurgery. The postsurgical changes remain. Hydrocephalus is discarded.

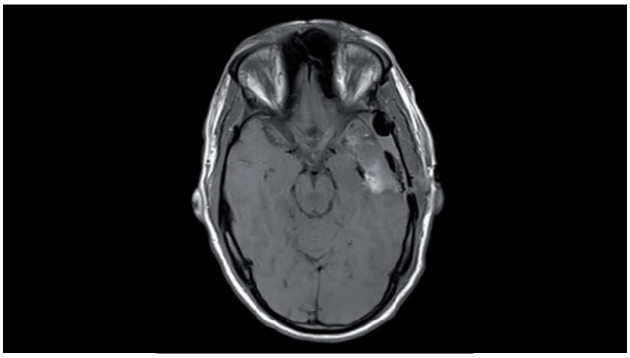

Image 3: Immediate postoperative control cranial MRI. Tumor resection area is seen with ventricular opening. Remains of epidural hematic collection related to the surgery.

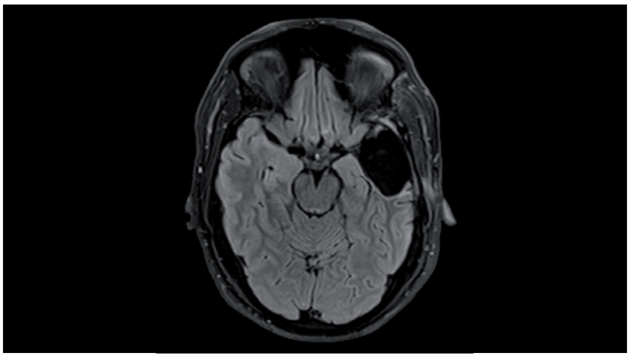

Image 5: Cranial MRI at four months after surgery. The area of the resection of the tumor remains without changes, hydrocephalus is discarded with complete resolution of the postsurgical epidural collection.

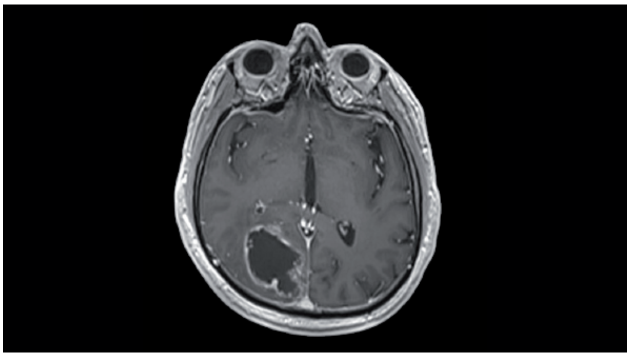

Image 6: Presurgical cranial MRI. Right occipital lesion can be seen in close relation to the right occipital. Lesion suggestive of high grade glioma.

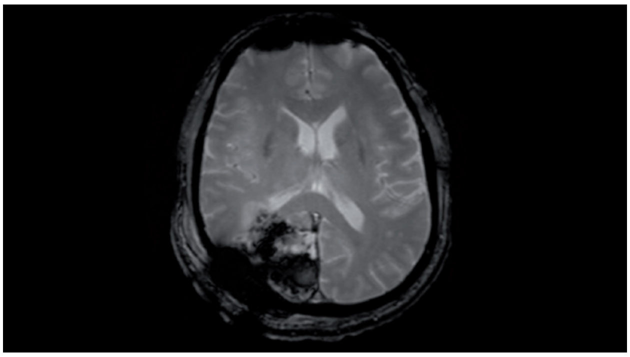

Image 7: Immediate postsurgical cranial MRI. Complete macroscopic resection of the lesion.

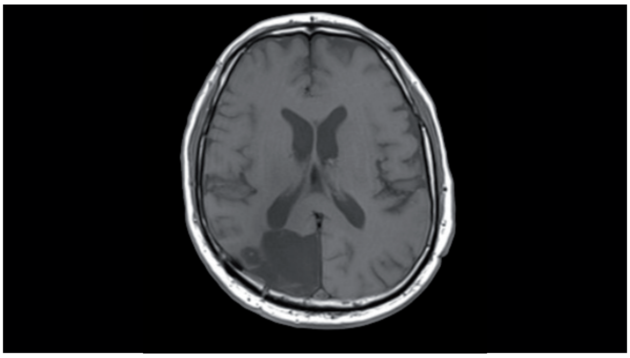

Image 8: Postsurgical cranial MRI at three months after surgery. Shows evolution of the postsurgical changes at three months after surgery without hydrocephalus nor accumulations suggestive of pseudomeningocele.

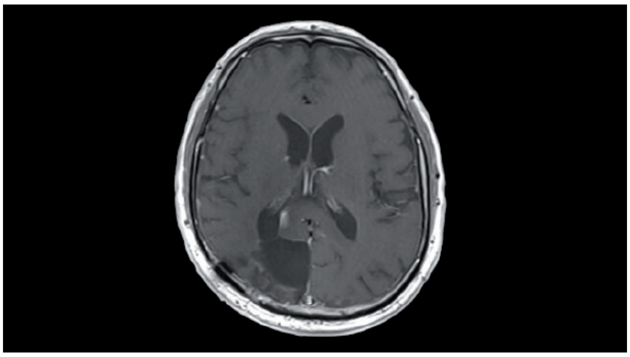

Image 9: Postsurgical cranial MRI at six months after surgery. Stability of the illness. No evidence of pseudomeningocele, hydrocephalus, or CSF fistula. No adverse reactions.

2nd Clinical case

- Male patient of 63 years old.
- **CH:** AHT (Arterial Hypertension). Psoriasis
- **Initial Clinical:** visual alteration of a month and a half evolution.
- Right occipital lesion can be seen in close proximity to the right occipital lobe. Lesion suggestive of high grade glioma.
- **Surgical intervention 06-09-21:** Occipital ventricular opening with placement of TachoSil® ventricular sealant. GTR.
- **CH:** Glioblastoma IDH1-R132H: negative ATRX: positive.
- The patient underwent standard treatment with adjuvant chemo- and radiotherapy. → *Image 8* shows evolution of the postsurgical changes at three months after surgery without hydrocephalus or accumulations suggestive of pseudomeningocele.
- At six months after surgery the patient remained neurologically stable. In → *Image 9* we see the image of the postsurgical cranial MRI at six months after surgery of the 2nd case where complications derived from open ventricular surgery were discarded.

Image 10: Preoperative MRI. Right occipital ring contrast-enhancing lesion, suggestive of high grade glioma.

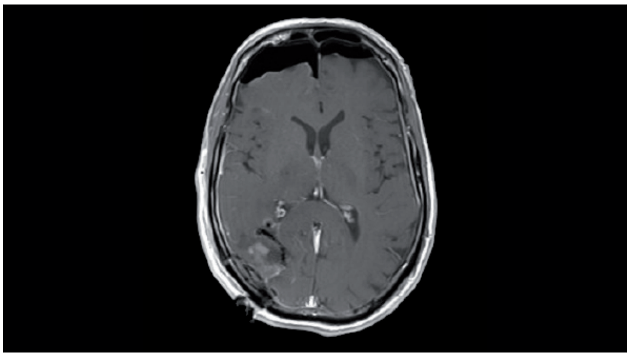

Image 11: Immediate postsurgical cranial MRI.

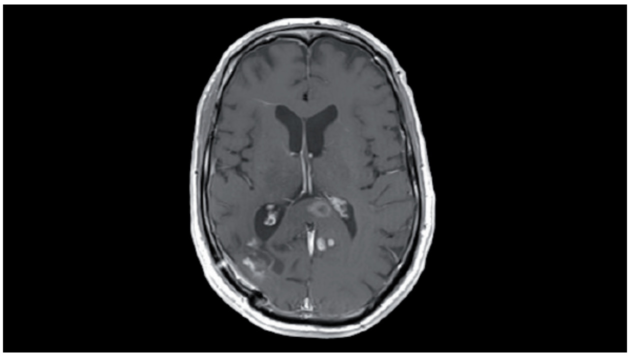

Image 12: Postsurgical cranial MRI at three months after surgery.

3rd Clinical case

- Male patient of 68 years old.
- **CH:** ex-smoker.
- **Initial clinical:** headache and disorientation of three weeks evolution.
- Diagnosis of right occipital ring contrast-enhancing lesion, suggestive of high grade glioma.
- The patient was treated in September 2021 through a right occipital craniotomy. Occipital ventricular opening with placement of TachoSil® ventricular sealant. GTR.
- A postoperative control MRI was performed showing a complete resection of the lesion and discarding secondary complications from the surgery.
- The Pathological anatomy confirmed that the lesion is a glioblastoma IDH1-R132H: negative ATRX: positive.
- At three months after surgery the patient presented progression of the lesion at the level of the corpus callosum and contralateral hemisphere. In → *Image 12* the postsurgical cranial MRI showed the image at three months after surgery in the 3rd case. No evidence of pseudomeningocele, hydrocephalus, or CSF fistula. No adverse reactions.

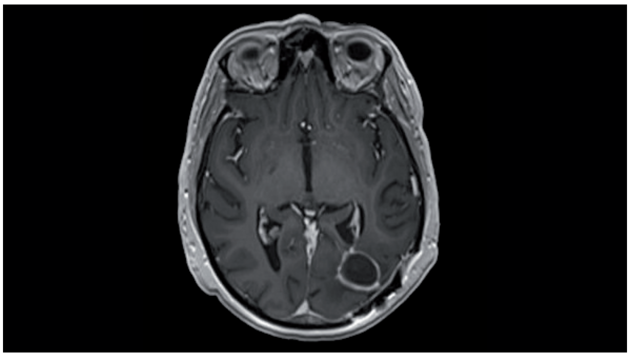

Image 13: Tumor progression at left occipital periventricular level to occipital level.

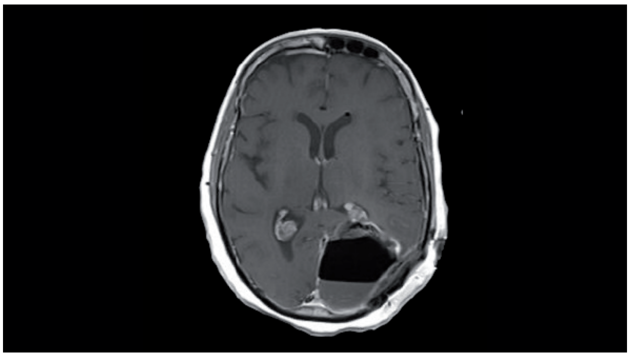

Image 14: Immediate cranial MRI. Secondary complications due to surgery are discarded.

4th Clinical case

- Female of 57 years old.
  HTA (hypertension arterialis).
- **Left occipital glioblastoma intervened on 03-26-21.** Debuts with asthenia and headache.
- In the → *Image 13* view of the tumor progression at left occipital periventricular level to occipital level.
- With this image we proceed to surgery.
- **Surgical rescue 02-17-22:** due to tumor progression. Occipital ventricular opening with placement of TachoSil® ventricular sealant. GTR.
- **CH:** Glioblastoma IDHwt (grade IV of malignancy WHO 2016). Non-mutated H3F3A. Non-methylated MGMT.
- In → *Image 14* the immediate postsurgical cranial MRI can be seen from the 4th case. Secondary complications due to surgery were discarded. No evidence of pseudomeningocele, hydrocephalus, or CSF fistula. No adverse reactions.

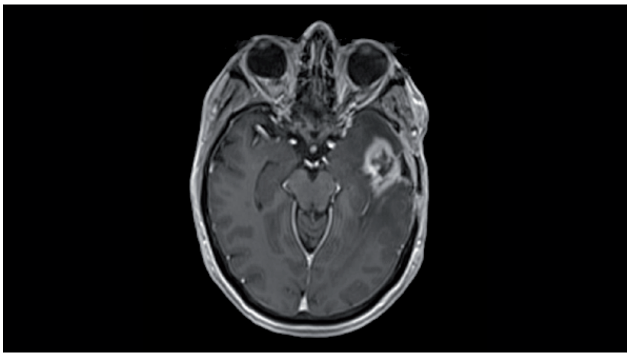

Image 15: Presurgical cranial MRI. Recurrence of left temporal lesion in contact up to left temporal.

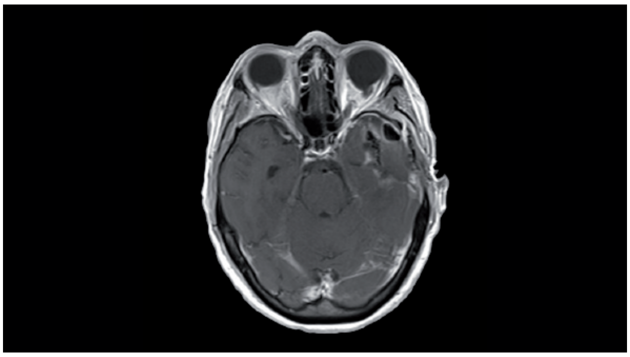

Image 16: Immediate postsurgical cranial MRI.

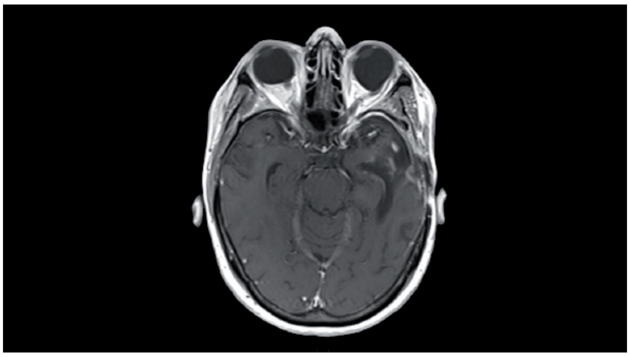

Image 17: Postsurgical cranial MRI at four months after surgery. No images of hydrocephalus, pseudomeningocele, or local complications in the region where the piece of TachoSil® was placed.

5th Clinical case

- Female of 65 years old.
- **CH:** HTA (hypertension arterialis), dyslipemia.
- **IQ:** histerectomy due to uterine myomas.
  IQ: 08-22-2019: Left temporal GBM IDH wt. Non-methylated MGMT. Complete resection. Debut with aphasia expression.
- **Initial clinical:** reappearance of language alteration with expression aphasia. Tumor progression so surgical rescue is proposed.
- **Surgical reintervention 04-07-21:** Temporal ventricle opening with placement of ventricular sealant with TachoSil®. Complete macroscopic resection. Favorable postoperative outcome.
- In the course of the evolution at four months of the reintervention, a new MRI is performed that discards complications resulting from the surgery. No evidence of pseudomeningocele, hydrocephalus, or CSF fistula. No adverse reactions.

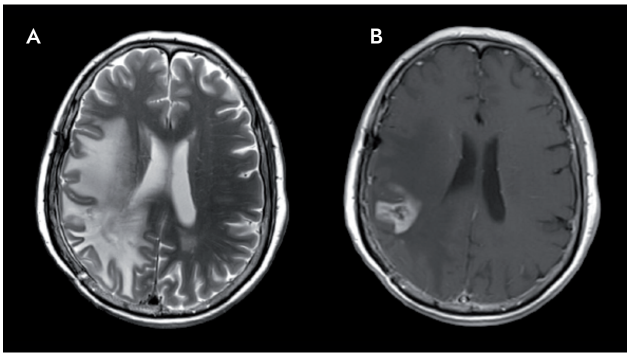

Image 18: A and B: Presurgical cranial MRI where a right parietal infiltrative lesion in contact with the right lateral ventricle is seen at the parietal level.

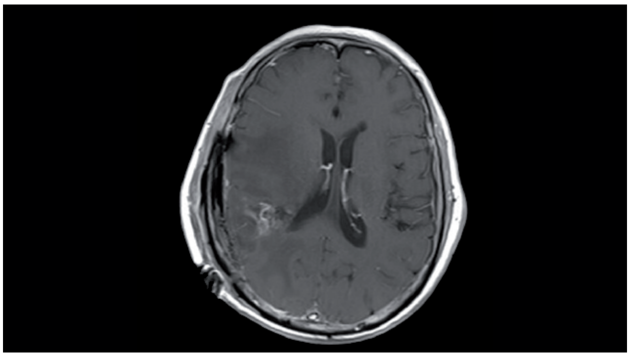

Image 19: Cranial MRI at six months after surgery. No evidence of pseudomeningocele, hydrocephalus, or CSF fistula. No adverse reactions.

6th Clinical case

- Female of 65 years old.
- **CH:** Right parietal craniotomy 07-11-18. Excision GBM IDH wt, ATRX positive.
- **Initial clinical:** Slight worsening of the initial symptoms of headache and clumsiness on with the left side of the body Progression of the tumor can be seen and surgical rescue is proposed with the patient awake for the language mapping *(→ Images 18A and B).*
- **Surgical reintervention IQ 02-25-21:** Temporal ventricle opening with placement of ventricular sealant with TachoSil®. GTR.
- **CH:** GBM IDH wt, ATRX positive.
- The patient presented a favorable postoperative evolution without complications resulting from the ventricular opening. No evidence of pseudo-meningocele, hydrocephalus, or CSF fistula. No adverse reactions *(→ Image 19).*

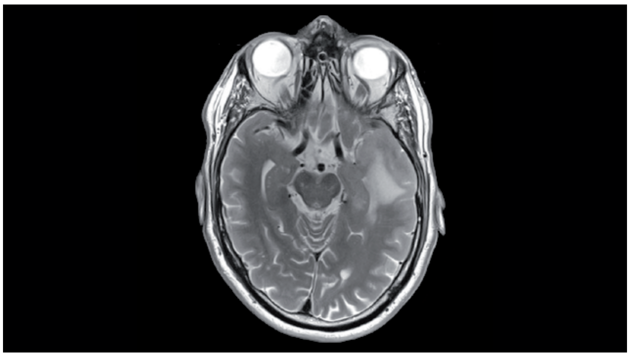

Image 20: Preoperative cranial MRI: Left temporal infiltrated lesion in contact up to left temporal. Minimum contrast uptake that, due to the age of the patient, would be more compatible with a high grade glioma.

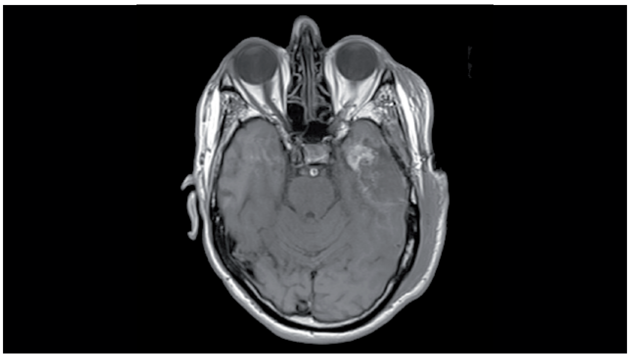

Image 21: Immediate postoperative control cranial MRI image. Subtotal resection of more than 95 % of the lesion.

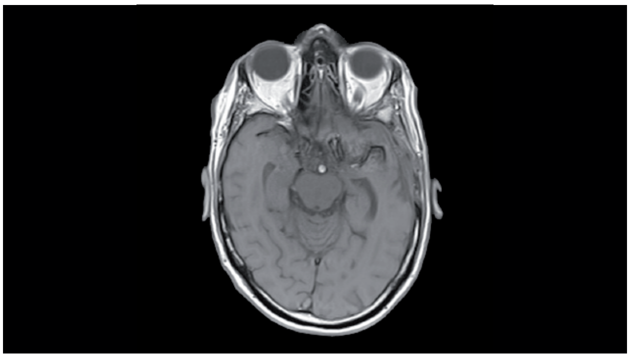

Image 22: Postoperative cranial MRI at six months after surgery.

7th Clinical case

- Male patient of 71 years old.
  Medical history of no clinical significance.
- Seizure crisis manifested with speech disorder recovered ad integrum.
- Diagnosed with left temporal infiltrated lesion in contact up to left temporal. Minimum contrast uptake that, due to the age of the patient, would be more compatible with a high grade glioma.
- **Surgical intervention 03-11-21:**
  Temporal ventricle opening with placement of ventricular sealant with TachoSil®. Subtotal resection of more than 95 % of the lesion.
- **CH:** GBM IDHwt.
- The patient presented a favorable postoperative evolution. The treatment was completed with adjuvant chemotherapy and radiotherapy. Imaging control at six months remained without evidence of pseudomeningocele, hydrocephalus, or CSF fistula. No adverse reactions to TachoSil®.

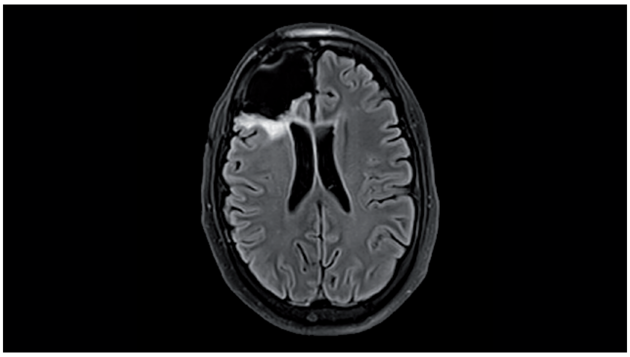

Image 23: Presurgical cranial MRI. Evidence of progression of the right frontal infiltrative lesion**.**

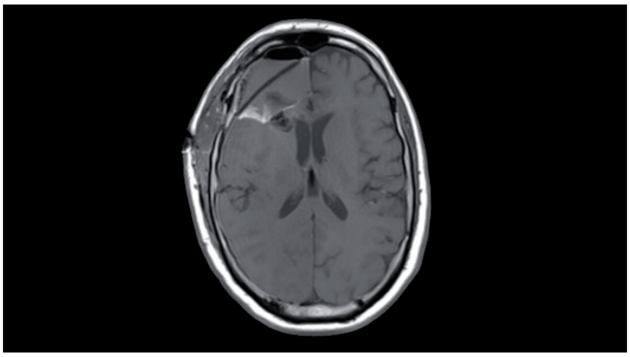

Image 24: Immediate postsurgical cranial MRI with complete resection of the lesion.

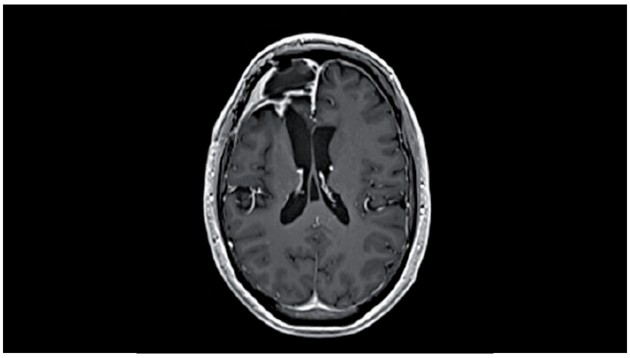

Image 25: Postsurgical cranial MRI at five months after surgery. Stable illness. No tumor progression. Postsurgical changes without hydrocephalus, or pseudomeningocele.

8th Clinical case

- Male patient of 43 years old.
  Medical history of no clinical significance.
- **Sensitive crisis. IQ 10-25-18:** Right frontal craniotomy IDH oligodendroglioma mutated codeletion 1p19q. Almost total resection.
- **Initial clinical:** Tumor progression.
  Surgical rescue of right frontal lesion.
- **Surgical reintervention on 07-28-21:** Frontal ventricle opening with placement of ventricular sealant with TachoSil®. GTR.
- The patient presented a favorable postoperatory.
- **Pathological anatomy confirmed the same as in the first intervention:** IDH oligodendroglioma mutated codeletion 1p19q.
- Evolution at five months of the surgery without complications.

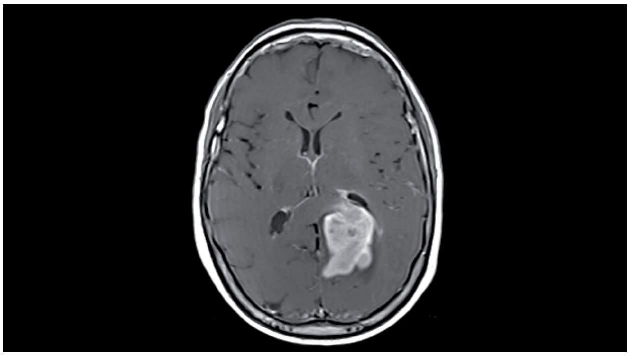

Image 26: Presurgical cranial MRI.

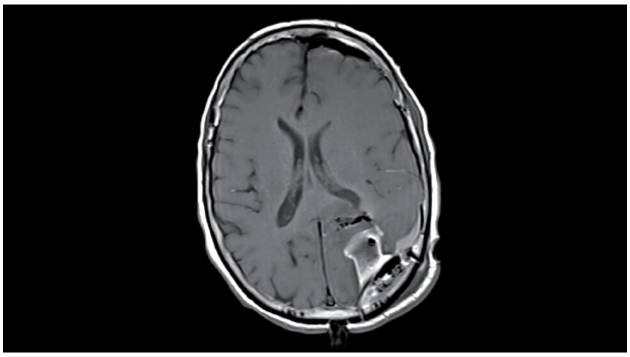

Image 27: Immediate postsurgical cranial MRI. Wide subtotal resection with infiltrative remains at the level of the spleen.

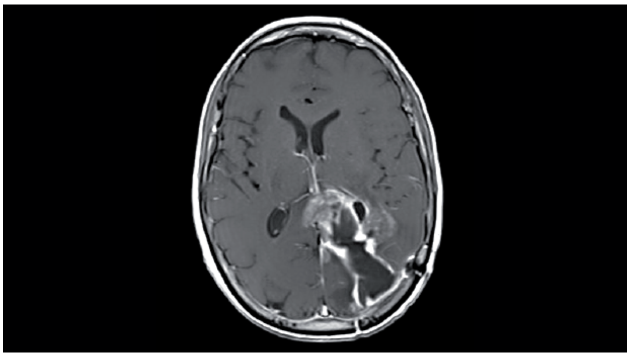

Image 28: Postsurgical cranial MRI at four months after surgery with evidence of progression of the tumor. No evidence of complications compatible with pseudomeningocele, hydrocephalus, or CSF fistula. No local adverse reactions.

9th Clinical case

- Female of 72 years old.
- **CH:** Polyarthritis.
- Venous insufficiency. Anxiety syndrome. Hysterectomy + adnexectomy. Bariatric surgery
- **Initial clinical:** Episodes of absence and visual disorders.
- Diagnosed with a lesion compatible with high grade left parietoccipital glioma.
- **Surgical intervention 10-25-21:** Occipital ventricular opening with placement of TachoSil® ventricular sealant. GTR.
- **CH:** GBM IDH wt, ATRX positive.
- The patient was treated with chemotherapy and radiotherapy after surgery but presented a clinical and radiological progression four months after surgery. A second line of chemotherapy treatment was proposed.
- No evidence of complications compatible with pseudomeningocele, hydrocephalus, or CSF fistula. No local adverse reactions.

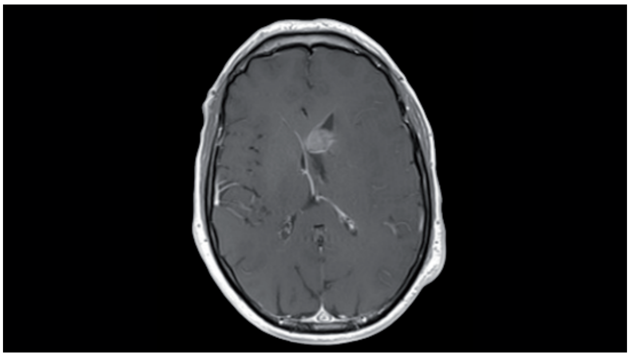

Image 29: Presurgical cranial MRI. Lesion compatible with left frontal glioblastoma in contact with the left frontal cortex with infiltration of the corpus callosum.

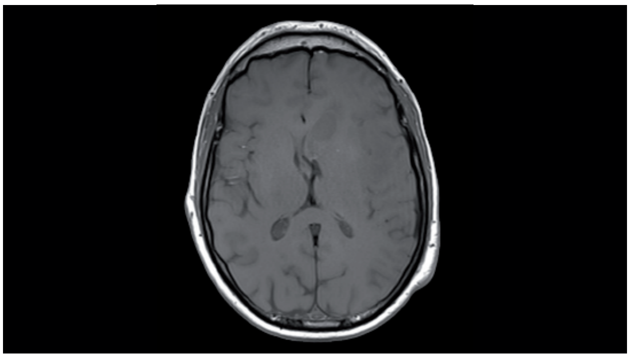

Image 30: Immediate postsurgical cranial MRI, with subtotal resection (tumor remnants that infiltrated the corpus callosum remain).

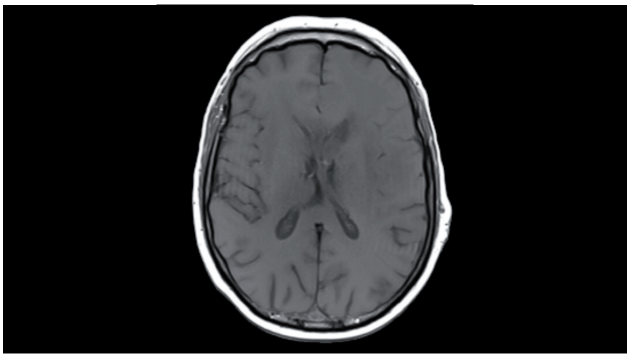

Image 31: Radiological control with cranial MRI at eight months postsurgery.

10th Clinical case

- Male patient of 50 years old.
- Complains of headache and fluctuating speech disturbance of two months of evolution.
- Diagnosed with left frontal temporal infiltrating lesion invading corpus callosum in contact with left frontal. Lesion compatible with high grade glioma.
- **Surgical intervention 12-10-20:** Frontal ventricular opening with placement of ventricular sealant with TachoSil®.
- **CH:** Non-mutated GBM IDH. Non-methylated.
- Radiological control with cranial MRI after eight months of surgery. Slight progression of the tumor remained at the level of the corpus callosum. No evidence of pseudomeningocele, hydrocephalus, or CSF fistula. No adverse reactions.

Discussion

Any procedure that requires opening the ventricle increases the postoperative risks, as described in detail in the Introduction.

We must consider that the incidence of these complications can be much greater in a determined profile of the patients as has previously been described, be it that the patients have had prior surgeries or treatments with radiotherapy in the intervened region.

This risks lead to an increase in the hospital stay, an increase in the risk of morbidity and mortality, lead to more infections and also greater risk of reintervention, as well as a greater probability of readmittance. All of this is associated with a substantial increase in the sanitary cost and the sensation of failure on behalf of the professional and the patient.

This is why neurosurgeons are obligated to take extreme measures during the closure of this type of surgery (ventricular opening). The use of dural sealants and dural plasties are almost indispensable in these cases but there is no product on the market today that is accepted for this particular local use.

Given that the indications of TachoSil® are as a hemostatic and in some types of surgeries it has implied its use at the intraparenchymal level (as a hemostatic of venous sinuses ...), we evaluate the possibility of placing a portion of this product right at the opening of the ventricle during surgery as is evidenced in the previously presented photo.

Conclusion

The use of TachoSil® at the intraparenchymal level for the ventricular seal is justified for the following reasons:

- Its use is authorized at the intracranial level (for hemostatic use: be it arterial or venous).
- It is easy to manipulate during surgery.
- It does not induce a reaction to a foreign body.
- It has scarce or null antigenicity.
- In the case that during the surgery it must be removed, it is simple to due so and carries no risks of injury at the parenchymal level.
- It is cost effective.
- It is easily available and to administer.
- It does not require special transportation or storage.
- It is easy to conserve.
- It insures us of impermeability between the ventricular system and the cerebral parenchyma.

In the cases presented no complications were derived from its use: no CSF fistula, pseudomeningocele, hydrocephalus nor regional infection. There was no patient with complications attributable to the use of TachoSil® in this location nor at the local or at the systemic level.

We consider the indication of this product to be safe and efficient for this localization. It can be used to considerably reduce the risk of complication in these type of patients principally in reinterventions or those with a history of radiotherapy/chemotherapy. In the series we have presented there existed patients that have been reintervened and reirradiated and none of them had complications after the ventricular opening after the surgery.

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25

Meningioma of the olfactory groove. Microsurgery and intra-extradural sealing with collagen enriched adhesive matrix with fibrinogen and thrombin

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Introduction

Meningiomas are generally benign tumors, of slow growth, originated in the meningothelial cells that are found in the arachnoid membrane. The represent approximately between 15 and 20 % of the intracranial tumors[1]. Although they can appear at any age, the highest incidence is during middle age, and are most frequent in the female sex[1]. Within the intracranial meningiomas, those that affect the base of the skull represent approximately 25 – 35 % of the cases.

The olfactory groove meningiomas (OGM) represent 10 – 15 % of the intracranial meningiomas according to different series, occupy the anterior fossa of the skull in the area of the cribose lamina and may envelop the Crista galli, the posterior part of the sphenoidal plane, and extend symmetrically on the midline, or laterally[2].

Due to the slow growth of the tumors in this location and the breadth of the anterior fossa, these tumors reach a large size, both in asymptomatic or oligosymptomatic form. The symptomology may appear as an alteration of the personality, behavioral changes, anosmia, headaches, loss of vision or epileptic crises[3].

The resection of these lesions with ample dural implantation, in addition to the anatomy of the base of the anterior fossa, implies a high risk of postoperative cerebrospinal fluid (CSF) fistula. In this case the use of the fibrinogen and thrombin matrix is described as a sealant of the cribose sheet.

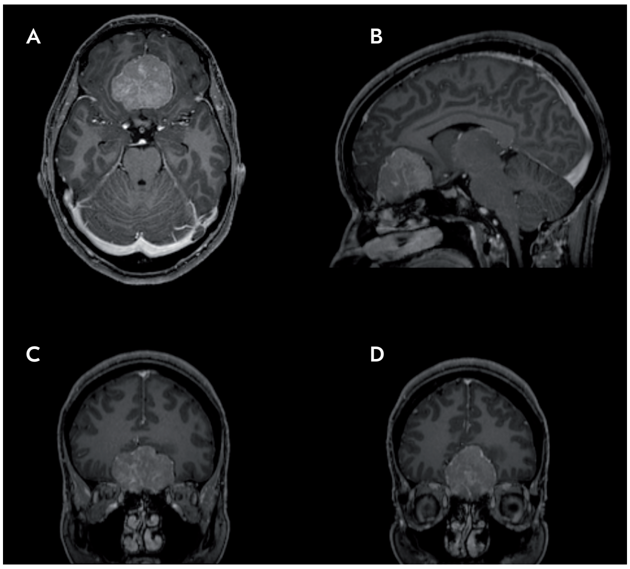

Image 1: Cranial magnetic resonance image sequenced in T1 with paramagnetic contrast. **A:** Axial slice where the extraaxial tumor at the anterior cranial fossa and the compression it exercises on both frontal lobes can be seen. **B:** Sagittal slice that shows the extension of the tumor in the antero-posterior axis and the bone erosion of the intracranial side of the frontal bone and ethmoid. **C and D:** Coronal slice where the maximum extension of the lesion in the lateral axis and cranial-caudal can be seen, respectively, and relation of the lesion with the olfactory groove.

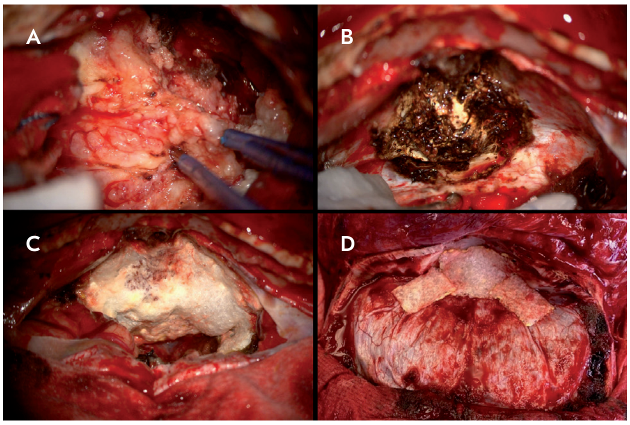

Image 2: Intraoperative image. **A:** View of the tumor lesion during the extirpation process through tumor debulking. **B:** View of the intracranial face of the frontal bone and ethmoids. The extirpation of the galli crista and the coagulation of the floor of the tumor implantation at the level of cribose sheet can be seen. **C:** View of the anterior cranial fossa sealed with the TachoSil® type collagen matrix. **D:** View of the sealing process of the dura mater through direct closure with non-absorbable suture and covering the surface of the incision line and frontal sinus with the TachoSil® type collagen matrix.

Clinical case

Female, 47 years old, without medical history, with symptoms of progressive headaches and olfactory loss of various months of evolution. The physical examination revealed a complete loss of smell. The rest of the examination was normal.

The cranial MRI showed an intracranial tumor of 44 x 35 x 40 mm in size located in the anterior cranial fossa with implantation in the base of the olfactory groove. The lesion produces bone erosion at the base of the skull and compression in both frontal lobes *(→ Image 1)*.

Surgical treatment consisting of a bifrontal craniotomy and complete macroscopic excision of the tumor lesion was performed in conjunction with coagulation of the adjacent dura mater (Simpson grade II). Given the elevated risk of CSF leakage it was decided to seal the cribose sheet with synthetic wax and TachoSil®, which stays completely adhered to the free bone walls. The cavity was filled with physiological fluid and absence of rhinolicuorrhea is verified. Afterwards the closure of the meninx and the frontal sinus was performed, using the eversion of an autologous pericranium flap and, once again, covering with TachoSil® *(→ Image 2)*.

The absence of CSF leakage through the dura mater was confirmed. After the surgery patient's condition improved. In the postoperative cranial CT there were no signs of hemorrhage or CSF leakage *(→ Image 3)*.

One month after the surgery, the patient continued with anosmia, but had considerable improvements with the headaches. In this time, the patient continued without complications associated to the procedure *(→ Image 4)*.

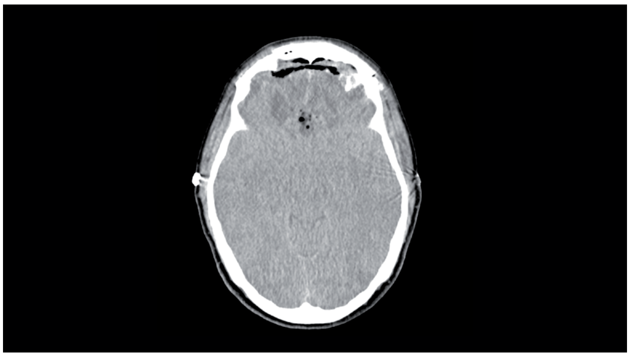

Image 3: Postoperative computerized tomography that shows the area of the tumor resection. Highlights the presence of intracranial air in the surgical bed, the distribution in the superior part and the separation of the same between the intradural and extradural compartment, which indicates an adequate sealing of the dura mater. In addition, no signs of hemorrhage or cerebrospinal fluid fistula are seen.

Image 4: Photo of the surgical wound twenty days after surgery. An adequate scarring of the wound can be seen as well as the absence of subcutaneous collections or other signs that suggest postoperative hemorrhage or cerebrospinal fluid fistula.

Discussion

Anatomically OGM originates in the dura mater of the Galli crista apophysis, in the anterior cranial fossa, on both sides sheets of ethmoid cribriforms are found, one that has multiple orifices where the nerve fillets of the first cranial nerve emerge with the sensory epithelium into the nasal cavity; in addition two major orifices are found, one anterior and the other posterior, through which penetrate the anterior and posterior ethmoidal arteries, and branches of the ophthalmic artery, which nourish the meningioma[2,3].

The resection of meningiomas in this location, especially after a complete resection with coagulation of the implantation dura mater, assumes an elevated risk of CSF fistula, which is fundamental for the reconstruction of the floor of the anterior cranial fossa in the closure.

In clinical practice the use of autologous material (pericranium, adipose tissue, muscular fascia), with synthetic patches of dura mater or sealants is common.

Conclusion

In this case, after the tumor resection, a seal was made with a fibrinogen and human thrombin matrix at the level of the cribose sheet, and a pediculated flap of autologous pericranium.

The patient evolved favorably, without evidence of CSF leakage, sin accumulation, nor problems associated with the wound.

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TachoSil SEALANT MATRIX

TachoSil® — four versions, three sizes*

Illustrated in original size

*Not all versions are available in all countries

TachoSil Sealant Matrix
(5.5 mg per cm^2 of human fibrinogen, 2.0 IU per cm^2 of human thrombin)

Statement: Before prescribing, consult/refer to the full prescribing information. **Presentation:** An off-white sealant matrix. The active side of the matrix is coated with fibrinogen and thrombin, is marked by a yellow colour. Supplied, ready to use, in sterile packaging. **Legal Classification:** Restricted prescription only medicine. **Indications:** In adults and children from 1 month old, for supportive treatment in surgery for improvement of haemostasis, to promote tissue sealing, and for suture support in vascular surgery where standard techniques are insufficient; also, in adults for supportive sealing of the dura mater to prevent postoperative cerebrospinal leakage following neurosurgical procedures. **Dosage & Administration:** For epilesional use only. Use is restricted to experienced surgeons. The quantity to be applied is governed by the size of wound area, and the underlying clinical need for the patient. In clinical studies, the individual dosages have typically ranged from 1-3 units (9.5 cm x 4.8 cm); application of up to 10 units has been reported. For smaller wounds, the smaller size matrices (4.8 cm x 4.8 cm or 3.0 cm x 2.5 cm) or the pre-rolled matrix (based on a matrix of 4.8 cm x 4.8 cm) is recommended. TachoSil should be used under sterile conditions and immediately after opening the inner sterile cover. Prior to application, the wound area should be cleansed, e.g. from blood, disinfectants and other fluids. For Flat TachoSil, the sterile package should be pre-moistened in saline solution and applied immediately. The yellow, active side of the matrix is applied to the bleeding/leaking surface and held against it with a gentle pressure for 3-5 minutes. For pre-rolled TachoSil, after removing from the sterile package, it should be applied immediately through the trocar without pre-moistening. The yellow, active side of the matrix is applied to the bleeding/leaking surface using e.g., a pair of cleansed forceps and held against it with a moist pad under gentle pressure for 3-5 minutes. Pressure is applied with moistened gloves or a moist pad. Avoid TachoSil sticking to surgical instruments, gloves or adjacent tissues covered with blood by cleansing them before application. After pressing TachoSil to the wound, the glove or the pad must be removed carefully. To avoid TachoSil from being pulled loose it may be held in place at one end, e.g. with a pair of forceps. In the case of stronger bleeding, it may be applied without pre-moistening, while also pressing gently to the wound for 3-5 minutes. The active side of TachoSil should be applied so that it extends 1-2 cm beyond the margins of the wound. If more than one matrix is used, they should overlap. TachoSil can be cut to the correct size and shaped if too large. In neurosurgery, TachoSil should be applied on top of the primary dura closure. **Contraindications:** Intravascular use; hypersensitivity to the active substances or to any of the excipients. **Warnings & Precautions:** No specific data available on the use of this product in gastrointestinal anastomoses surgery. Life threatening thromboembolic complications may occur if the preparation is applied intravascularly. Allergic type hypersensitivity reactions are possible, as with any protein product. If hypersensitivity reactions occur, the administration must be discontinued immediately. To prevent the development of tissue adhesions at undesired sites, ensure tissue areas outside the desired application area are adequately cleansed before administration. In the case of shock, the current medical standards for shock treatment should be followed. Standard measures to prevent infections resulting from the use of medicinal products prepared from human blood or plasma include selection of donors, screening of individual donations and plasma pools for specific markers of infection and the inclusion of effective manufacturing steps for the inactivation/removal of viruses. Measures taken are considered effective for enveloped viruses such as HIV, HBV and HCV and for the non-enveloped virus HAV. Measures may be of limited value against non-enveloped viruses such as parvovirus B19. Parvovirus B19 infection may be serious for pregnant women (foetal infection) and for individuals with immunodeficiency or increased erythropoiesis (e.g., haemolytic anaemia). It is recommended to record the name and the batch number of the product administered to the patient. Some cases of product non-adhesion issues have been reported in the form of lack of product adhesion / lack of efficacy. Correct product handling and application is required **Interactions:** No interaction studies have been performed. Similar to comparable products or thrombin solutions, the sealant may be denatured after exposure to solutions containing alcohol, iodine, or heavy metals. Such substances should be removed to the greatest possible extent before applying the sealant. **Fertility, Pregnancy & Lactation:** Safety for use in human pregnancy or breastfeeding has not been established in the clinical studies. Only administer to pregnant and breastfeeding women if clearly needed. **Effects on Ability to Drive and Use Machines:** Not relevant. **Undesirable Effects:** Hypersensitivity or allergic reactions (in isolated cases these reactions may progress to severe anaphylaxis; some cases of product residue causing granuloma), thromboembolic complications may occur if used intravascularly, and adhesions and intestinal obstruction when used in abdominal surgery. Refer to the SmPC for details on full side effect profile and interactions. **Overdose information:** No case of overdose has been reported. **Interactions with Other Medicinal Products:** No interaction studies have been performed. Similar to comparable products or thrombin solutions, the sealant may be denatured after exposure to solutions containing alcohol, iodine or heavy metals (e.g., antiseptic solutions). Such substances should be removed to the greatest possible extent before applying the sealant. **Use in Special Populations:** Limited data are available to support efficacy and safety of TachoSil in the paediatric population. In clinical studies, a total of 36 paediatric patients aged 0-13 years were treated with TachoSil in hepatic surgery. **Pack Sizes:** Package with 1 matrix of 9.5 cm x 4.8 cm, Package with 2 matrices of 4.8 cm x 4.8 cm, Package with 1 matrix of 3.0 cm x 2.5 cm, Package with 5 matrices of 3.0 cm x 2.5 cm, Package with 1 pre-rolled matrix of 4.8 cm x 4.8 cm. Not all pack sizes may be marketed.

Marketing Authorisation Holder: Corza Medical GmbH,
Speditionstraße 21, 40221 Düsseldorf, Germany
The full SmPC can be obtained from Corza Medical GmbH.
Marketing Authorisation Numbers: EU/1/04/277/001-005

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Link to Full SmPC or Prescribing information