Descompressive Craniectomy in Aneurysms surgery. When and how to do it?

Craniectomia descompresiva en cirugía de aneurismas. Cuando y cómo realizarla?

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Resumen

Introducción: La Craniectomía Descompresiva es una técnica quirúrgica conocida desde hace más de un siglo, sin embargo, su utilidad ha sido debatida por diferentes neurocirujanos a lo largo de los años. Después del año 1998, la técnica pasó a ser utilizada de forma significativa para una amplia variedad de patologías en las que la hipertensión intracraneal tiene comportamiento refractario. La técnica de descompresión intracraneal aumenta la complacencia, disminuye la presión intracraneal y aumenta la presión de perfusión cerebral con preservación del tejido. **Objetivo:** Nuestro objetivo es establecer cuándo y cómo realizar la Craniectomía Descompresiva frente a una complicación de la Hemorragia Subaracnóidea Aneurismática o cirugía de aneurismas no rotos. **Metodología**: Se realizó un universo transversal mediante la revisión de los prontuarios de pacientes sometidos a craniectomia descompresiva debido a la hemorragia subaracnoidea aneurismática o aneurismas no rotos. Los procedimientos se realizaron en el Servicio de Neurocirugía de la Santa Casa de Misericordia de Ribeirão Preto, SP. **Resultados**: Del año 2010 a 2014, se realizaron 144 craniectomías, siendo 37 por aneurismas (22 rotos); (3%), grado II: 14 casos (64%), grado III: 1 caso (4%), grado II: 7 casos (32%), grado II: 14 casos (64%), grado III: 1 caso (4%); (2%), Fisher 2: 3 casos (14%), Fisher 3: 5 casos (23%), Fisher 4: 8 casos (36%), 15 casos no rotos. La edad media de los pacientes fue de 48 años. 22 casos (60%) sobrevivieron (14 asintomáticos, 4 con déficit, 2 síntomas menores, 2 pérdida de seguimiento); 15 casos (40%) fallecieron. Se produjo 10 casos reoperados, siendo 1 caso el mismo día, 4 casos en el 2º día y 5 casos en el tercer día. De estos, 4 (40%) sobrevivieron y 6 (60%) fallecieron. Complicaciones de las reoperaciones: 1 hidrocefalia, 3 is-quios, 4 hematomas intraparenquimatosos, 2 hipertensiones refractarias. Hunt-Hess y Fisher altos fueron los de peor pronóstico. Las complicaciones que resultaron en craniectomia fueron hematomas, isquemia, edema o asociaciones, asimetría y desviación de la línea media mayor que 0,5 cm. **Discusión**: El objetivo de la Craniectomía descompresiva es reducir la presión intracraneal, independientemente del factor causal, cuando la PIC se eleva a valores alarmantes. En 1940, Erlich sugirió la realización de Craniectomía Descompresiva para todas las lesiones craneales con coma persistente por más de 24-48 horas. Rowbotham, en 1942, recomendó la técnica para todos los comas traumáticos en que el tratamiento clínico fue ineficaz por 12 horas. Los pacientes con HSA severa a menudo poseen un pronóstico malo, no obstante, sobre la base de los resultados alentadores de la Craniectomía Descompresiva en el tratamiento de los TCE y AVCi, hay crecientes relatos de la efectividad de la craneiectomía descompresiva en el tratamiento de HSA. Conclusión: Craniectomía Descompresiva reduce la hipertensión intracraneal con disminución de la morbimortalidad. No indicamos craniectomías localizadas por el riesgo de isquemia en los bordes y empeoramiento clínico. La cirugía precoz evoluciona con mejores resultados, menor número de muertes y fortalece la relación médico-paciente. La monitorización de la presión intracraneal (PIC) es fundamental, sobre todo en los casos limítrofes, en los que la decisión sobre la realización de la craniectomía es un desafío en el primer momento.

Palabras clave: Craniectomía Decompresiva, aneurismas cerebrales, hipertensión endocraneana.

Abstract

Introduction: Decompressive craniectomy is a surgical technique known for more than a century, however its usefulness has been debated by different neurosurgeons over the years. After 1998, the technique was used in a significant way for a wide variety of pathologies in which intracranial hypertension has a refractory behavior. The Intracranial Decompression Technique increases compliance, decreases intracranial pressure, and increases cerebral perfusion pressure with tissue preservation. **Objective**: Our goal is to establish when and how to perform decompressive craniectomy in the presence of a complication of aneurysmal subarachnoid hemorrhage or surgery of unbroken aneurysms. **Methods**: A cross-sectional study was carried out by reviewing the medical records of patients submitted to decompressive craniectomy due to aneurysmal subarachnoid hemorrhage or unbroken aneurysms. The procedures were performed at the Neurosurgery Service of the Santa Casa de Misericórdia in Ribeirão Preto. **Results**: From 2010 to 2014, 144 craniectomies were performed, 37 of which were due to aneurysms (22 ruptures); Hunt-Hess classification: grade I: 7 cases (32%), grade II: 14 cases (64%), grade III: 1 case (4%); Fisher classification: Fisher 1: 6 cases (27%), Fisher 2: 3 cases (14%), Fisher 3: 5 cases (23%), Fisher 4: 8 cases (36%), 15 cases not broken. The mean age of the patients was 48 years. 22 cases (60%) survived (14 asymptomatic, 4 with deficits, 2 minor symptoms, 2 loss of follow-up); 15 cases (40%) died. There were 10 cases reoperated, 1 case on the same day, 4 cases on day 2 and 5 cases on day 3. Of these, 4 (40%) survived and 6 (60%) died. Complications of reoperations: 1 hydrocephalus, 3 ischemias, 4 intraparenchymal hematomas, 2 refractory hypertension. Hunt-Hess and Fisher were those with the worst prognosis. Complications that resulted in craniectomy were hematomas, ischemia, edema or associations, asymmetry and mean line deviation greater than 0.5 cm. In relation to Bifrontal and Posterior Fossa we did not obtain cases of complicated aneurysms in these areas. **Discussion**: The purpose of decompressive craniectomy is to decrease intracranial pressure, regardless of causal factor, when PIC rises to alarming values. In 1940, Erlich suggested performing a Decompressive Craniectomy for all cranial lesions with persistent coma for more than 24-48 hours. Rowbotham in 1942 recommended the technique for all traumatic commas in which clinical treatment was ineffective for 12 hours. Patients with severe SAH often have poor prognosis, however, based on the encouraging results of Decompressive Craniectomy in the treatment of TBIs and CVA, there are increasing reports of successful decompression Craniectomy in the treatment of SAH. **Conclusion**: Decompressive craniectomy reduces intracranial hypertension with a decrease in morbidity and mortality. We did not indicate localized craniectomies due to the risk of border ischemia and clinical worsening. Early surgery evolves with better results, fewer deaths and strengthens physician-patient relationship. Intracranial pressure monitoring (ICP) is essential, especially in borderline cases, in which the decision about performing the craniectomy is a challenge in the first moment.

Key words: Decompresive craniectomy, cerebral aneurysms, intracranial hypertension.

Introduction

The descrompressive creniectomy is a surgical technique known for more than a century, but its utility variated from none to everything according to neurosurgeons. Actually, it reappears after the papers of Guerra from 1998 and is utilised for a wide range of pathologies, from traumatic to vascular and tumoral, but all realising an refractory intracranial pressure[1].

The first decompressive craniectomies were presented by Kocher in 1901, Cushing in 1903 and Horsley in 1906, in a period when most surgery was realized through a large "exploratory" bone flap - when no lesion was found, some authors suggested removing the bone flap to decompress the brain from the lesion. Unfortunately, the aesthetical results were disastrous and led to limiting the technique. In traumatic pathology the method knew supporters and detractors[2]: Erlich (1940) suggested a decompressive craniectomy for all head injuries with persistant coma for more than 24-48 hours - without a specific diagnosis most cases woul have died anyway. Rowbotham (1942) recommanded decompressive craniectomy for all traumatic comas which improved at first and when medical treatment was ineffective for 12 hours. Munro (1952) suggested that if intraop the brain was contused and swollen to realize a large craniectomy and opening the dura mater[3]. Among adversaries are Mayfield, Lewin, Moody, whose papers during 1960-1970 note a high mortality rate for the technique and discourage its utilisation. After the introduction of CT scan, in 1975 , Ramshoff, Morantz and others present series of comatose patients wiht acute subdural hematomas, operated during the first 6-12 hours, with decompressive craniectomies realized by necessity. Despite technical and esthetical problems, they report a survival rate of 40% with 27 % return back to a previous life - however the method doesn't meet a genereal approval. The desert of redescovering the decompressive craniectomy belongs to Guerra in 1999 who presents in Journal of Neurosurgery his personal results of 20 years of decompressive craniectomy using CT scan and ICP monitoring. His good results lead to the acceptance of the technique as second-tier therapy for refractory intracranial pressure[4,5]. The following 5 years know more than 50 papers dedicated to decompressive craniectomy leading to sections of neurosurgical meeting dedicated to the technique and at least 2 prospective double blind multicentric studies in going on its indication in traumatic pathology[6,7]. Decompressive craniectomy (DC) is an effective method of managing rises in intracranial pressure (ICP) that are refractory to medical therapy. Randomised controlled studies have demonstrated favourable outcomes in malignant cerebral artery infarction[8,9,10]. Increasingly, DC is used to control ICP in subarachnoid haemorrhage (SAH) both as a primary and secondary procedure.

Objetives

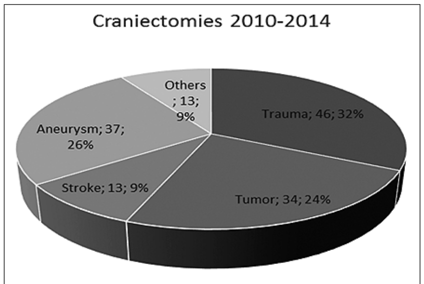
Our goal is to establish when and how to perform decompressive craniectomy in the presence of a complication of aneurysmal subarachnoid hemorrhage or surgery of unbroken aneurysms.

Methods

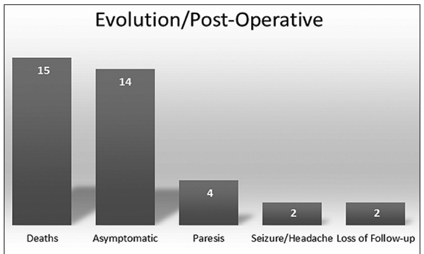
A cross-sectional study was carried out by reviewing the medical records of patients submitted to decompressive craniectomy due to aneurysmal subarachnoid hemorrhage or unbroken aneurysms. The procedures were performed at the Neurosurgery Service of the Santa Casa de Misericórdia in Ribeirão Preto.

Results

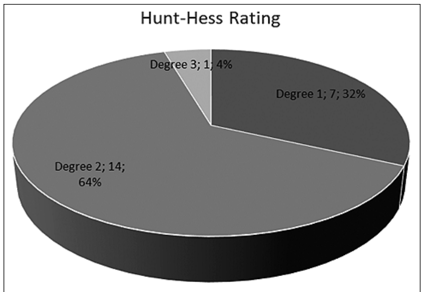
From 2010 to 2014, 144 craniectomies were performed in our service, 37 of which were due to aneurysms (22 ruptures) (Graph 1). Hunt-Hess classification: grade I: 7 cases (32%), grade II: 14 cases (64%), grade III: 1 case (4%); Fisher classification: Fisher 1: 6 cases (27%), Fisher 2: 3 cases (14%), Fisher 3: 5 cases (23%), Fisher 4: 8 cases (36%), 15 cases not broken. The mean age of the patients was 48 years, being 30-40 years: 6 patients, 40-50 years: 13 patients, 50-60 years: 14 patients and over 60 years: 4 patients. The radiological exams used were Computed Tomography of the skull and Angiography. Intracranial pressure (ICP) was monitored in 11 cases. The operative technique was: Fronto-Parieto-Temporo-Occipital Craniectomy, 15 cm in diameter, from the orbital border, lambdoid suture, 1.5 cm from the sagittal suture, to the base of the middle fossa. The opening of the dura mater was made in starry appearance. We report 22 cases (60%) of survival (14 asymptomatic patients, 4 patients with deficits, 2 patients with minor symptoms and 2 patients with loss of follow-up). The number of deaths was 15 cases (40%). 27 patients underwent direct craniectomy; at the main time, 19 (70%) survived and 8 (30%) died, 4 cases (50%) per infection, 1 case (12%) due to cardiac decompensation and 3 cases (38%) due to severe intracranial hypertension. There were 10 cases reoperated, 1 case on the same day, 4 cases on day 2 and 5 cases on day 3. Of these, 4 (40%) survived and 6 (60%) died (Graph 2). Complications occurred in reoperations: 1 case of hydrocephalus, 3 cases of ischemia, 4 intraparenchymal hematomas and 2 refractory intracranial hypertension. It was not possible to monitor all cases due to problems with covenants and Hospital. Hunt-Hess and Fisher were those with the worst prognosis (Graph 3, 4). Complications that resulted in craniectomy were hematomas, ischemia, edema or associations, asymmetry and mean line deviation greater than 0.5 cm. In relation to Bifrontal and Posterior Fossa we did not obtain cases of complicated aneurysms in these areas (Graph 5, 6, 7).



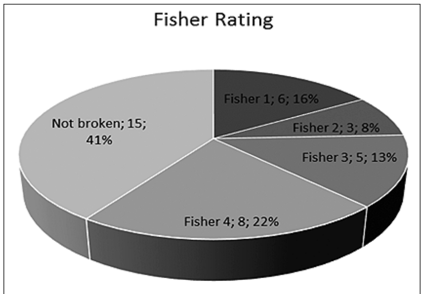
Graph 1. Total of craniectomies performed in the service of the year 2010 to 2014, classified according to etiology.



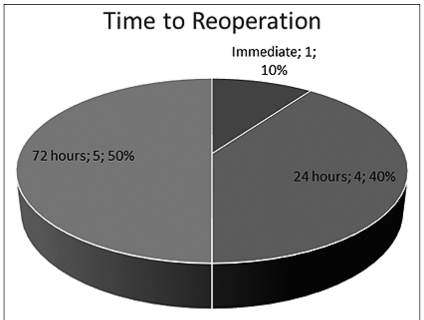
Graph 2. Evolution and Post-Operative of patients submitted to Decompressive Craniectomy.



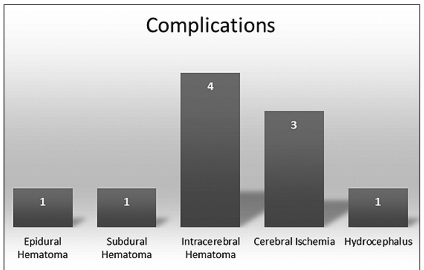
Graph 3. Hunt-Hess Classification of Patients with Subarachnoid Hemorrhage.



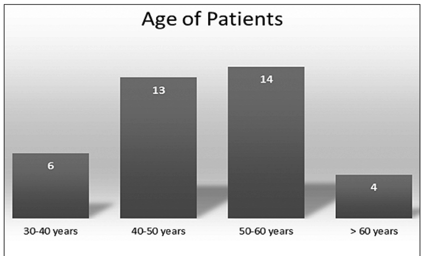
Graph 4. Fisher Classification of Patients with Subarachnoid Hemorrhage.



Graph 5. Time to re-approach patients in the necessary cases.



Graph 6. Complications of reoperated cases.



Graph 7. Description of the age of patients undergoing decompressive craniectomy in the study.

Discussion

Physiopathology

The purpose of decompressive craniectomy is to diminish the intracranial pressure, no matter it's the lesion, when ICP raises to alarming values. The threshold of ICP variates from children, which tolerate larger values when sutures are still open, to adults and according to phatology. The limits of well tolerated ICP, together with lowering of CPP, variate from 18-20 mmHg in subarachnoid hemorrhage, 20-22 mmHg for malignant sylvian stroke, 25 mmHg for trauma and 30-40 mmHg for slow growing tumors and hydrocephalus[5]. Some of these values are among what is considered a normal ICP but with an ailing brain. When medical treatment becomes ineffective, the decompression realizes an enlargement of the intracranial space, preventing a further raise of ICP and cerebral herniations. Moreover, Doppler and perfusion MRI studies showed an increase of blood flow in leptomeningeal vessels, an increase of backward flow in the sylvian artery together with the perfusion of the isquemic penumbra area. In order to realize a real decompression, we need to evaluate the volume gained on surgeryconsidering a circular craniectomy and a bulging of just 10% of the surface to prevent ischemia on the bone flap's edge. Apparently a craniectomy of 8 cm large would appear large enough but in fact it gives just 23 ml additional volume so 1,5% of total cerebral volume. To obtain a real decompression, most authors recommend a minimum diameter of 12 cm or more (86 ml additional volume). The additional volume obtained by a decompressive craniectomy is consequently superior to the one realized by hyperventilation (2 ml/mm of lowering pCO2); superior to a ventricular tap of 20-30 ml and without the risk of rebound of loop diuretics[5]. Patients with poor grade SAH often have poor outcomes[11]. Drawing on the encouraging findings following DC in the management of TBI and MCA infarction, there are increasing reports of retrospective case series describing the role of DC in the management of SAH[12,13,14,15]. It may be part of the primary procedure, ie the bone flap is left out at the time of clipping the aneurysm, or as a secondary procedure, when patient deterioration is secondary to uncontrollable rises in ICP. Patients with large haematomas undergoing primary or secondary DC have significantly better outcomes (mRS 0-3, p value = 0.038) than those treated for oedema and delayed ischaemic infarctions. It is recognised that DC combined with dural opening and duraplasty leads to a reduction in ICP which leads to an immediate and significant improvement of tissue perfusion and oxygenation.[16]. Decompression enables re-opening of previously compressed collateral blood vessels which improves brain perfusion. The loss of perfusion in SAH is often due to diffuse small vessel vasospasm and hence decompressing the intracranial space is unlikely to aid reperfusion[17].

Operative techniques and advances

Decompressive craniectomies vary principally in location, size and shape of the bone deficit as well as the management of the dura. Historically, circular craniotomy and sub-temporal decompression were performed most, but both resulted in small apertures and are now widely regarded to be suboptimal in the treatment of refractory raised ICP[18,19]. Presently, for lesions or swelling confined to one cerebral hemisphere, a large unilateral fronto-temporoparietal craniectomy is performed. For more diffuse swelling a bi-frontal craniectomy, from the floor of the anterior cranial fossa to the coronal suture posteriorly and to the pterion inferiorly is performed (Figures 1A and B). There exist slight differences between centres, with some leaving a strip of bone over the superior sagittal suture during a bifrontal craniotomy, in effect removing two symmetrical frontal bone flaps. There is also a difference of opinion as to whether the falx should be divided. Discussing these differences in technique are beyond the scope of this article. The size of the craniectomy is the primary determinant of the magnitude of ICP reduction[20]. Randomised prospective analysis of standard and limited craniectomy flap of 12 x 15 cm and 6 x 8 cm respectively has demonstrated greater reduction in ICP and better outcomes in the larger DC flap[20]. It is widely accepted that craniectomy without dural opening only produces a partial decrease in ICP, with maximal reduction in ICP only achieved following opening of the dura. The dura may be opened by several methods, but most common incisions are either reflections

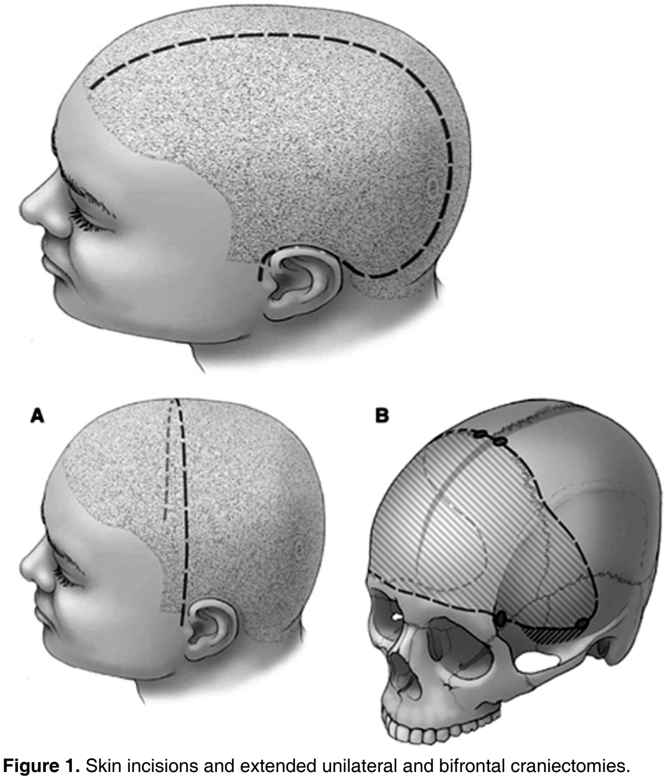


Figure 1. Skin incisions and extended unilateral and bifrontal craniectomies.

of the dura or the creation of a cruciate, stellate lattice. No trial data or consensus exists to suggest the superiority of any one method. The practice of primary duraplasty with either pericanium or a dural substitute has been suggested to lower the risk of complications such as subdural hygromas, CSF leak, infection, and neurologic injury from scalp adhesions to underlying brain[21]. It is also suggested to make cranioplasty both safer and easier. However, no conclusive data exists to prove this and it will often come down to individual surgical preference. No surgical technique is exempt of complications and decompressive craniectomy is no exception. Acute complications:

- Hemorrahgic contusions at the level of the decompressed brain- Classical complications, characteristic to traumatic pathology, is due to lowering the intracranial pressure to normal values, but allowing hemorrhage from anterior compressed capillaries. It does not represent a complication but a normal evolution of the lesion and there is no way to prevent it.
- Fongus cerebri, the herniation of the brain ("mushroom''), at the level of the bone flap is most frequent the result of a bone flap not enough large, when cerebral decompression is not sufficient and high intracranial pressure displaces the already contused brain through a small breech in the skull- aspect wide known to neurosurgeons, especially for acute subdural hematomas.
- The development of contralateral hematomas especially acute subdural or epidural was already described, its mechanism being similar to hemorrhagic contusions, though bleeding from a bridge vein or a bone fracture. These hematomas are characteristic to traumatic pathology decompressed in the first 24 h.
- Wound dehiscence is frequent due to the high pressure from interior which maintains sutures in tensions and concomitant ischemic/necrotic phenomena due to a low blood supply for the flap´s dimensions. It occurs more frequent when accidently coagulating the superficial temporal artery when realizing the skin flap.
- Late complications: Postraumatic hydrocephalus, problems connected to cranioplasty, infections and trephined syndrome[22].

Conclusion

Decompressive craniectomy reduces intracranial hypertension with a decrease in morbidity and mortality. We did not indicate localized craniectomies due to the risk of border ischemia and clinical worsening. Early surgery evolves with better results, fewer deaths and strengthens physician-patient relationship. Intracranial pressure monitoring (ICP) is essential, especially in borderline cases, in which the decision about performing the craniectomy is a challenge in the first moment.

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