REVIEW ARTICLE

Decompressive craniectomy: indications and techniques

Craniotomia descompressiva: indicações e técnicas

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ABSTRACT

Introduction: Decompressive craniectomy (DC) is a surgical method indicated for immediate reduction of intracranial pressure (ICP) in general facing brain swelling, acute subdural hematoma, and some non-traumatic diseases. The technique consists of craniectomy and expansion of the dura-mater to accommodate the swollen brain. **Literature review:** several studies with DC indications show distinct results. There is no evidence to justify its routine use in adults with serious traumatic brain injury (TBI); however, it is indicated in children. **Discussion:** the refractoriness of intracranial hypertension (ICH) towards clinical measures is an indirect finding of cerebral auto-regulation loss, which configures the presence of Brain Swelling (BS), or swelling of the brain. DC is indicated in cases of BS, being bi- (Marshall III) or unilateral (Marshall IV). The technique requires broad bone removal, greater than the usually used in bruises and contusions. The incision in 'T'- Kemp is preferred for allowing broad access to the frontotemporoparietal regions and great bone decompression. After craniectomy, dural diaeresis followed by duroplastia is conducted and, finally with the replacement of the bone flap to its original location after bulging reduction. **Conclusion:** DC is effective in immediately reducing ICP, avoiding ICH, which is a factor for poor prognosis. Its usefulness is especially observed if carried out prematurely in TBI victims with ICH when compared to being carried out late and with clinical measures of ICP control such as barbiturate coma and hypothermia.

Key words: Craniocerebral Trauma; Craniotomy; Intracranial Hypertension.

RESUMO

Introdução: *a craniotomia descompressiva (CD) é método cirúrgico indicado para a redução imediata da pressão intracraniana (PIC) em geral, diante de tumefação cerebral, hematoma subdural agudo e algumas doenças não traumáticas. A técnica consiste em craniotomia e ampliação da dura-máter para se acomodar o cérebro tumefeito.* ***Revisão da literatura:*** *vários estudos com indicações de CD apresentam resultados distintos entre si. Não existem evidências que justifiquem sua aplicação de rotina em adultos com traumatismo cranioencefálico (TCE) grave, mas em crianças parece que sim.* ***Discussão:*** *a refratariedade da hipertensão intracraniana (HIC) às medidas clínicas é achado indireto de perda da autorregulação cerebral, o que configura a presença de um Brain Swelling (BS), ou tumefação cerebral. A CD está indicada nos casos de BS, seja bi (Marshall III) ou unilateral (Marshall IV). A técnica do procedimento requer a retirada óssea ampla, maior que as usualmente utilizadas nos hematomas e contusões, sendo preferencial a incisão em 'T'- Kemp, por permitir acesso amplo às regiões frontotemporoparietal e grande descompressão óssea. Após a craniotomia, procede-se à diérese dural seguida de duroplastia e, por fim, recolocação do flap ósseo ao seu local original, após redução do abaulamento.* ***Conclusão:*** *a CD é eficaz em reduzir imediatamente a PIC, evitando-se a HIC, que é fator de mau prognóstico. Sua utilidade é especialmente observada se realizada precocemente em vítimas de TCE e com HIC quando comparada à sua realização*

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tardia e com medidas clínicas de controle da PIC, como coma barbitúrico e hipotermia.

Palavras-chave: Traumatismos Craniocerebrais; Craniotomia; Hipertensão Intracraniana.

INTRODUCTION

Decompressive craniectomy (DC) is a surgical method used for the immediate reduction of intracranial pressure (ICP). It is generally indicated in cases of brain swelling, acute subdural hematoma (ASDH) and non-traumatic diseases.[1] It consists of craniectomy and expansion of the dura mater to accommodate the swollen brain. The bone can be temporarily housed in the abdominal subcutaneous tissue or be ignored until a subsequent cranioplasty with acrylic. In these cases, the correct term would be decompressive craniectomy.

Conducts in relation to trauma were systematized in 1996 by classifying them according to scientific evidences in guidelines or options for assistance in traumatic brain injury (TBI).[2] These guidelines were updated in 2000, with DC being suggested as the second option (second tier) for the treatment of intracranial hypertension (ICH), however, without validation by class I studies.

This technique was widely used in the 70s and 80s, however, with disappointing results. It was applied only when all clinical attempts to reduce ICH clinics had already failed.[3,4] The control of ICH was tried through clinical measures (barbiturate coma, hypothermia), which also showed reduced effectiveness and frequent clinical complications.[5-9]

Recently, studies have been assessing the effectiveness of DC when applied early in patients who are victims of severe TBI with ICH, showing superior results in late application or when compared to specific clinical measures (barbiturate coma and hypothermia).[10-14]

REVIEW OF THE LITERATURE

There is no doubt that DC is an effective technique to immediately reduce ICP, avoiding ICH, which in itself is a bad prognostic factor.

Polin et al.[15], in an attempt to a more homogeneous comparison between the two groups, retrospectively studied 35 patients with refractory brain swelling and undergoing bi-frontal DC. The authors used patients treated with barbiturate coma extracted from the Traumatic Coma Data Bank (TCDB) as the control group. The surgical group showed a statistically significant improvement compared to the conservative group control. The pediatric population evolved better and those operated after 48 hours evolved unfavorably. The mortality rate was reported as 23%, and favorable evolution as 37%. The procedure is indicated early in patients with ICP of less than 40 mmHg and with more than three points on the Glasgow Coma Scale (GCS). We highlight the episode of 10 patients (28.5%) who developed hydrocephalus, dependent of ventricular derivation, after the procedure.

Guerra et al.[12], in 1999, evaluated 57 patients undergoing DC (26 patients with bilateral craniectomy and 31 with unilateral craniectomy). They obtained better results than the previous series, probably because of a rigorous selection of candidates and early performance of DC. They reported a mortality rate of 19%, with good functional rehabilitation in 58%. ECG and ICP in the first postoperative day were the most important prognostic indicators. The complications reported were: 14% hydrocephalus, 26% hygroma, 7% post-operative seizures, and 2% infection. There was no mortality directly related to the technique. Therefore, they indicate DC in patients younger than 50 years old, with signs of brain swelling, without primary irreversible lesion, and with refractory ICH or responsible for neurological worsening.

Munch et al.[16] retrospectively evaluated 49 patients undergoing unilateral DC by pairing them with a control group of barbiturate coma from the TCDB. The prognosis (Glasgow Outcome Score-GOS) at ICU discharge was similar in both groups, however, with significant improvement in the surgical group when evaluated after six months. An improved evolution was observed in patients under the age of 50 years and operated early in the surgical group. The appearance of the mesencephalic cistern in brain injury correlated with the prognosis, even when the midline deviation was unchanged. They obtained 20% of good results, with 33% mortality.

Faleiro et al.[17] evaluated prognostic factors and complications in 89 patients undergoing unilateral DC in closed brain injury cases. The statistically significant prognostic factor was the ECG on admission, and the major complications were liquor malabsorption, such as hydrocephalus (7.9%) and subdural collection (11.2%).

The Cochrane systematic review concluded that there is no scientific evidence to justify the routine implementation of DC in adults with severe TBI, emphasizing only the study by Taylor, in 2001, with positive evidence in the pediatric population.[18,19]

DECRA

The DECRA was a multicenter study (15 tertiary hospitals) that randomized 155 patients to evaluate the effectiveness of bi-frontal craniectomy (BC) in relation to the prognosis (modified GOS). These patients were randomized for BC or conventional clinical treatment if they showed refractory ICH (> 20 mmHg for more than 15 minutes). In summary, the study showed that in the BC group, the time of mechanical ventilation and ICU stay were shorter, however, when evaluated belatedly, these patients were functionally worst (modified GOS) than those in the conservative treatment group.

This study should be evaluated with caution because its definition of refractory ICH (20 mmHg for 15 minutes) is fairly low; current centers tolerate ICP up to 25 mmHg, especially if the cerebral perfusion pressure (CPP) is at optimal levels. Therefore, many patients received BC when it was not needed.

Another criticism lies on the chosen technique. The authors describe a similar technique to that used in the study by Polin et al.[18] but without cutting the brain scythe. It is known that BC is related to poor functional results, especially when the brain scythe is cut, because the cerebral frontal lobes advance and are harmed against the dural fold with patients becoming frontalized lately. The study shows that BC is not a good technique to be used, and therefore, bilateral craniectomy is preferable to bifrontal craniectomy.

A careful analysis of the statistical data shows that 18% of patients in the conservative group were craniectomized as a life-saving measure; however, their results were analyzed as conservative. More importantly, 27% of patients from the craniectomy group had bilateral mydriasis against only 12% in the conservative group. There was no statistical difference in long-term functionality between the two groups when the patients with mydriasis were removed from both groups.

Unfortunately, DECRA did not respond to the main issues related to DC.

DISCUSSION

Indications

Most clinical measures for the treatment of ICH act in the intracranial blood compartment – arterial or venous. The cerebral self-regulation needs to be intact so that such measures, such as hyperventilation and hypertonic solution or mannitol exert their effects. The refractoriness of ICH to the clinical measures is an indirect finding of self-regulation loss, i.e. Brain Swelling (BS) or swelling of the brain occurs.

DC is indicated in cases of BS, be it bilateral (Marshall III) or unilateral (Marshall IV). This pathophysiological concept also helps to understand the appropriate time to complete DC. See Marshall classification (Table 1).

Table 1 - Marshall classification

Type	Tomographic description	Prognosis
I	Tomography without visible pathologies.	9.6% mortality
II	Cisterns present; midline deviation 0-5 mm; absence of lesions > 25 ml.	13.5% mortality
III	Compressed cisterns or absent; midline deviation 0-5 mm; absence of lesions > 25 ml.	34% mortality
IV	Midline deviation > 5 mm; absence of lesions > 25 ml.	56.2% mortality

Source: Marshall SB, Marshall LF, Klauber MR et al. The new classification of head injury based on computerized tomography. J Neurosurg 1991; 75: S14-S20.

On the Marshall IV CT (Figure 1), there is unilateral loss of self-regulation and any clinical measurement that act in the blood compartment will act in the healthy hemisphere, worsening the midline deviation (MLD). In these cases, the DC conduct is early, with the placement of an ICP monitor after the procedure, and patient transfer to the ICU.

Figure 1 - Marshall IV (MLD = 6 mm).
Source: author's collection.

In the Marshall III CT (Figure 2), the MLD is less than 5 mm, however, there is a closure of the basal cisterns and lateral ventricles. These patients should receive ICP monitoring measures and ICH aggressive treatment in the ICU. In cases of treatment refractoriness, one must resort to DC, which can be unilateral in cases of MLD. In cases where there is neither the least deviation in the pellucidum septum, the bilateral DC is chosen. This technique is preferred over the bifrontal because it is associated to worsen functional prognosis as a consequence of frontalized patients or akinetic mutism, especially when the brain scythe is not cut (DECRA).

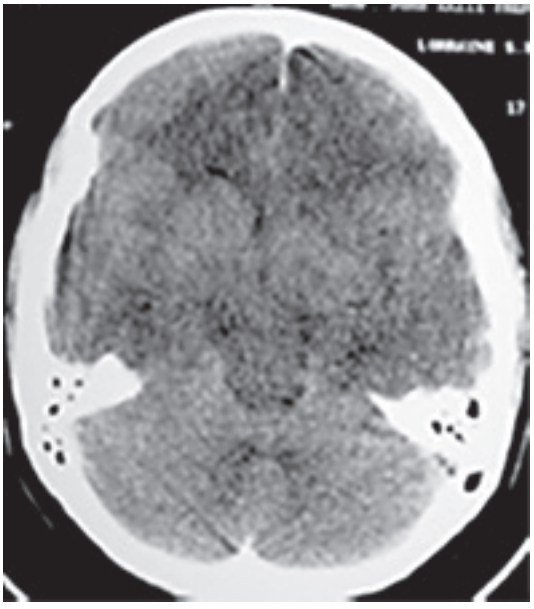

Figure 2 - Marshall III (MLD < 5 mm and base cisterns erased).
Source: author's collection.

There are two types of patients with ASDH. The first refers to the young, trauma victim with great acceleration-deceleration. A laminar hematoma is usually found in these cases, with MLD disproportionate to the hematoma size. This suggests unilateral BS and indication for DC. The other type is concerned an older patient, alcoholic, or with blood dyscrasia, with low kinetic energy trauma (fall from own height, stairs), who develops voluminous hematoma by cerebral atrophy and great MLD, proportional to the hematoma size. In these cases, craniectomy is indicated for the hematoma drainage with replacement of the bone flap in its original position.

Technique

There are two types of incision described in the literature: one as an inverted question mark, or Becker type, also known as trauma flap for being used in the drainage of most hematomas or post-traumatic contusions. In the decompression technique, a wide bone removal is indicated (12 to 14 cm in its greatest diameter), greater than those usually applied in hematomas and contusions. The occurrence of skin necrosis is not rare in the attempt to increase this incision after the auricle (Figure 3).

Figure 3 - Skin necrosis in Becker type incision.
Source: author's collection.

For this reason, the incision in 'T' is preferred, described for hemispherectomies by Ludwig G. Kempe. This type of incision ensures secure access to frontotemporoparietal regions, allowing wide bone decompression.[4] Special attention should be given to the removal of bones, up to the base of the middle fossa, because this measure will enable the opening of the basal cistern.

Once craniectomy is performed, the dural diaeresis is followed by duroplasty. There are several incision and dura mater plasty techniques. At this point, it should be emphasized that whatever technique is employed, it must allow homogeneous expansion of the brain tissue. The pericranium is used in the duroplasty. The hermetic dural suture with prolene 4 or 5 thread is preferable (Figure 5).

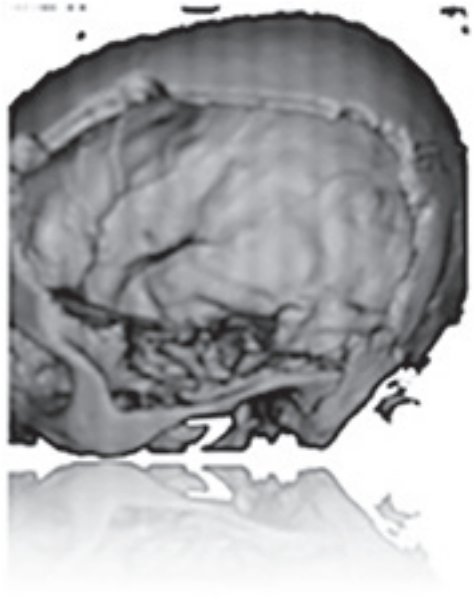

Figure 4 - Broad craniectomy with resection of the temporal bar.
Source: author's collection.

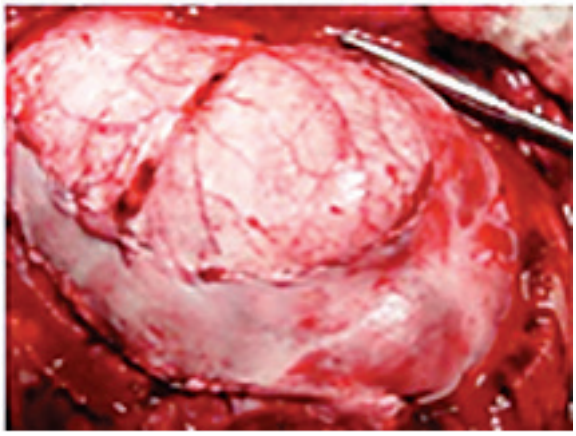

Figure 5 - Hermetic duroplasty.
Source: author's collection.

The detection of hydrocephalus or subdural collections after DC is frequent, and the hermetic dural suture decreases the incidence of liquor fistula.[17,20]

Finally, the bone must be stored in the abdominal subcutaneous tissue. The transversal infraumbilical incision, Pfannestiel type, was initially performed for that purpose, however, it was observed that a direct contact with the diaper and secretions could be associated with high rates of infection, which made the paraumbilical incision preferred (Figure 6).

The bone flap should be replaced in its original location as soon a reduction in bulging, in the craniectomy area, is observed. It is believed that the earlier the cranioplasty, the lower the incidence of hydrocephalus or subdural collections, in addition to a proven improvement in the subjacent cerebral cortex function.[21]

Figura 6 - Umbilical incision.
Source: author's collection.

CONCLUSION

Hence, it is evident that DC is an effective technique to immediately reduce the ICP, preventing ICH, which is a poor prognosis factor itself. It applies to patients with refractory clinical measures ICH (Marshall III) or those who arrive with major midline deviation (Marshall IV). The surgery should be avoided in patients with three points in the ECG, no reflections in the brainstem, and cranial computed tomography showing irreversible lesions.

The main complications from the technique are liquor malabsorption (such as hydrocephalus and subdural collection), hygroma, postoperative convulsion, and infection.

The early performance of DC in victims with severe TBI and ICH seems to be associated with superior results compared to its late application or specific clinical measures (barbiturate coma and hypothermia).

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