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DECOMPRESSIVE CRANIOTOMY

Prognostic factors and complications in 89 patients

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Abstract – Decompressive craniotomy (DC) is applied to treat post-traumatic intracranial hypertension (ICH). The purpose of this study is to identify prognostic factors and complications of unilateral DC. Eighty-nine patients submited to unilateral DC were retrospectively analyzed over a period of 30 months. Qui square independent test and Fisher test were used to identify prognostic factors. The majority of patients were male (87%). Traffic accidents had occurred in 47% of the cases. 64% of the patients had suffered severe head injury, while pupillary abnormalities were already present in 34%. Brain swelling plus acute subdural hematoma were the most common tomographic findings (64%). Complications occurred in 34.8% of the patients: subdural effusions in 10 (11.2%), hydrocephalus in 7 (7.9%) and infection in 14 (15.7%). The admittance Glasgow coma scale was a statistically significant predictor of outcome (p=0.0309).

KEY WORDS: head injury, intracranial hypertension, decompressive craniotomy.

Craniotomia descompressiva: análise de fatores prognósticos e complicações em 89 pacientes

Resumo – A craniotomia descompressiva (CD) é técnica utilizada para tratamento da hipertensão intracraniana (HIC) pós-traumática. O objetivo do estudo foi determinar fatores prognósticos e complicações nos pacientes submetidos a esta técnica. Realizou-se estudo retrospectivo de 89 pacientes submetidos à CD unilateral para tratamento da HIC pós-traumática durante 30 meses. Utilizou-se testes do Qui-quadrado de independência e teste exato de Fisher para análise de fatores independentes de prognóstico. A maioria dos pacientes era do sexo masculino (87%). A causa mais comum foi o acidente de trânsito (47%). A maioria apresentava traumatismo cranioencefálico grave (64%), 34% já apresentavam anisocoria. O achado tomográfico mais comum foi a associação entre tumefação cerebral e hematoma subdural agudo (64%). Em 34,8% dos pacientes houve complicações inerentes à técnica: coleção subdural (11,2%), hidrocefalia (7,9%) e infecção (15,7%). A escala de coma de Glasgow à admissão correlacionou-se estatisticamente como fator prognóstico (p=0,0309).

PALAVRAS-CHAVE: traumatismo cranio-encefálico, hipertensão intracraniana, craniotomia descompressiva.

Decompressive craniotomy (DC) is a surgical method performed to immediately reduce intracranial pressure (ICP). It is usually indicated in cases of brain swelling (BS) and acute subdural hematoma (ASDH), or even for non-traumautic lesions in order to accommodate the swollen brain[1]. It consists of a unilateral craniotomy and dural augmentation. The bone can be temporarily stored in the abdominal subcutaneous tissue or can be disposed in case of a subsequent cranioplasty (with methylmethacrylate or titanium plate, among other materials).

Recent studies have been evaluating DC efficacy when performed early in patients with severe traumatic brain injury (TBI) and with intracranial hypertension (ICH), yielding a superior result as compared to late performance or to specific clinical procedures (barbiturate coma and hypothermia)[2-6].

The purpose of this study was to evaluate prognostic factors and complications in 89 patients submitted to DC over a period of 30 months.

METHOD

A retrospective study was carried out with 89 TBI patients submitted to DC from January, 2003 through July, 2005 (30

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months), at Hospital Pronto Socorro João XXIII (an emergency unit), in Belo Horizonte MG, Brazil. The project was approved by the hospital Reasearch Ethics Committee.

Patients submitted to unilateral DC for treatment of blunt head injury were included in the study. Exclusion criteria were: patients submitted to unilateral DC for treatment of hemispheric ischemic stroke or encephalic lesion by firearm bullet (open trauma). Bilateral DC patients were also excluded.

A protocol was used to obtain data from the records selected by the hospital statistics division (SAME), as shown below:

Epidemiological data

Patient's age, trauma etiology, GCS at admittance, focal neurological deficit at admittance, polytrauma or not. According to GCS results patients were grouped as severe TBI (GCS=3–8), moderate TBI (GCS=9–13) or mild TBI (GCS=14 and 15).

GCS at admittance – The first rating registered by the neurosurgeon in the admittance record was considered. In cases of patients arriving intubated and sedated without an GCS rating in subsequent developments, the rating registered by the paramedics before intubation was accepted.

Tomographic data

Pre-operatory tomographic findings were classified as: isolated BS or hemispheric BS associated with acute extradural hematoma (AEDH), acute subdural hematoma (ASDH) or brain contusion.

Preoperative data

Availability of ICU before surgery, duration of surgical procedure as related to hospital admittance time (<6 h, 6–24 h and >24 h), destination of bone flap removed (abdominal subcutaneous tissue or disposal) and duroplasty technique (hermetic or not).

Time elapsed between admittance and surgery was obtained from the admittance form. An arbitrary classification was made: very early surgery (less than 6 hours after admittance), early surgery (between 6 and 24 hours) and late surgery (after 24 hours).

Postoperative data

Availability of ICU after surgery, ICP monitoring, complications (subdural effusions, hydrocephalus, infection, CSF leak) and neurological status at discharge from hospital and after a minimum period of six months. The Glasgow outcome scale - GOS was used for evaluation. After six months GOS evaluation was carried out by telephone with patient's or relative's previous information and consent.

In order to reduce the number of variables in the statistic evaluation, GOS 1 and 2 were grouped as bad outcome, and GOS 3, 4 e 5 as favorable outcome. This outcome was not called *good* because the group included patients with significant neurological deficit, GOS 3.

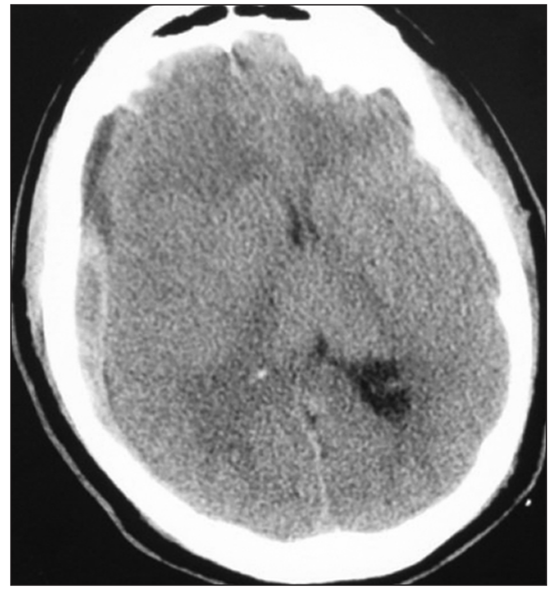

Fig 1. Acute subdural hematoma on the right, with midline shift not proportional to the hematoma thickness.

The surgical technique for DC respected the principles of large scalp incision, large craniotomy and opening of the dura mater. Extra-axial hematomas or contusions were drained. Dural augmentation was performed with pericranium and hermetic seam or left open, according to the surgeon's preference. The bone flap, also at the surgeon's discretion, was stored in the abdominal subcutaneous tissue or disposed and cranioplasty was performed subsequently.

An attempt was made to correlate discharge prognosis factors by means of Qui square independence tests and Fisher test for the following variables: age, anisocoria, polytrauma, GCS upon admittance, tomographical findings and post-operatory ICH. $p<0.05$ was considered a significant result.

89 patients were studied, but complete data could not be obtained for all of them. Therefore each item was calculated according to the total data obtained (for example, as far as age is concerned, frequency was calculated in 80 patients, anisocoria in 75 patients, GCS upon admittance in 81 patients).

RESULTS

89 victims of TBI in which DC was performed were analyzed. Most patients were male (87%), between 21 and 50 years of age (70%). The most common cause was traffic accident (automobile accident and being run over – 47%), followed by falls (36%). Most patients had severe TBI (GCS≤8) (64%), and 32% of the patients showed signals of imminent death (anisocoria or bilateral mydriasis). 31 patients (39%) had polytrauma. The most frequent tomographic finding was the association of BS and ASDH in 51 patients (62.9%) (Fig 1). Other findings were isolated BS in 12 (14.8%), BS+AEDH in 11 (13.5%) and bilateral BS in 6 (7.4%). Cerebral contusion was an associated finding in 46.9% of tomographies.

In most patients (76%), the indication for DC was based upon ICH indirect findings seen in the CT scan (midline shift, obliteration of basal cisterns and of the third ventricle). Patients whose indirect criteria were not definitive were admitted in the ICU for ICP monitoring and submitted to the general medical and clinical procedures for ICH treatment such as positioning, mannitol and hyperventilation. If procedures fail, barbiturate coma was applied during a specified time (up to 6 hours), after which DC was performed. Following this protocol, 21 patients (23.5%) were treated in the ICU before surgery, and barbiturate coma was necessary for 6 of them before DC.

DC was performed early (less than 6 hours after admittance) in 20 patients (22.4%), and late (after 24 hours) in 36 (40.4%).

After surgery 65 patients were admitted in the ICU (73%), where ICP was monitored in 51 of them. There was at least one occurrence of ICH in 26 patients (51%).

Complications inherent to the surgical technique occurred in 34.8% of the patients: subdural effusions in 10 patients (11.3%), hydrocephalus in 7 (7.9%) and infection in 14 (15.9%): four of these were meningitis, and the others were superficial (in the surgical wound). Three patients had CSF leak in the surgical wound.

The evolution of the present series, according to the Glasgow outcome scale (GOS), was obtained in 88 patients (one was operated on at the hospital and transferred to another institution on the next day):

- GOS 1 (death): 48 cases (54.5%)
- GOS 2 (vegetative state): 2 cases (2.3%)
- GOS 3 (major neurological deficit): 15 cases (17.0%)
- GOS 4 (minor neurological deficit): 13 cases (14.7%)
- GOS 5 (good functional recovery): 10 cases (11.3%)

It was possible to evaluate 30 patients after 6 months (taking the 48 deaths into consideration, we have a total of 78 patients) with the following conditions: GOS 2, one patient; GOS 3, eight patients; GOS 4, twelve patients; and GOS 5, nine patients.

GCS upon admission was correlated as prognosis , with $p<0.05$ ($p=0.0309$) (Table).

Table. Glasgow coma scale (GCS) and prognosis.

Glasgow admittance	GOS		Total
	Favorable	Bad	
Mild TBI	2	4	6
Moderate TBI	14	9	23
Severe TBI	15	37	52
Total	31	50	81

Value p=0.0309; TBI, traumatic brain injury; GOS, Glasgow outcome scale.

DISCUSSION

DC is not a new technique, as it has been used since the 1970's[7-9]. At that time, the procedure was performed late when all other procedures had failed and the patient generally showed signs of cerebral herniation, being in a deep coma with signs of anisocoria or even bilateral mydriasis. Many times the procedure avoided death, but left the patient in a vetetative state. In 1976, in spite of the previous work reporting benefits as a consequence of DC, Cooper et al., came to the conclusion that the technique should be abandoned because of poor outcome[10].

Over the past two decades, there was a revival of DC to treat ICH, with results that proved superior to the previous series[2-4,11]. But what has changed? There is no doubt that part of the improvement owes to technological advances in intensive care, transportation to hospital and ATLS recommendations that, according to Marmarou et al. ,reduced mortality as a result of severe TBI from 50% to 36%[12].

Upon specific analysis of DC, several factors could be mentioned as responsible for such an improvement:

Time – It is an accepted fact in medical literature that the earlier the removal of hematomas or factors that increase ICP, the better the results. This fact is confirmed in Seelig et al., where a considerable reduction of death is shown when patients with ASDH were operated on before 4 hours after admittance to hospital[13]. Therefore one of the main differences in new practices is early DC, that often replaces clinical procedures such as hyperventilation, hypothermia or barbiturate coma[4,11,14] . But when we look closely at the series considered in this study, we notice that DC was performed very early (<6 h) in 22.7% of the patients, early (6-24 h) in 36.4% and late (>24 h) in 40.9%. Comparing results in each subgroup, it can be observed that death occurred in 59% of patients operated earlier and in 53% of those operated later. This can be explained by the fact that the DC group is heterogeneous. Patients operated earlier are often in worse clinical conditions and present midline shifts greater than 5 mm. Others can be admitted to the ICU with monitored ICP and initially respond to clinical treatment. Refractory ICH can develop several days after admittance, and DC is performed. This explanation is confirmed in a European multicenter study[15].

Selection and formation of group studied – Epidemiological factors that constitute the sample of patients under study can affect results. Ransohoff et al. came upon death in 60% of patients and favorable outcome in 28%[7]. Guerra et al. came upon death in 19% and good rehabilitation in 58% of patients submitted to DC[4]. While evaluating the subjects under study it can be observed that all patients in the first study already presented pupillary abnormalities before surgery (five had bilateral mydriasis), which may have affected results negatively. In the second study, DC was performed only in patients under 50 years of age and with CT scans that did not evidence irreversible lesions. Polin et al. performed DC only in patients withs GCS >3 and ICP <40 mmHg; death rate was 23%[11]. Aarabi et al. analyzed the main series published, with a total of 323 patients[14]. General death rate was 22.3% and satisfactory evolution was found in 48.3% patients.

This study has presented worse results in comparison with the international series. Death rate was 54.5% (48 patients) and 43% of patients (38) had favorable outcome, two of which remained in a vegetative state. Some factors may have contributed negatively to the results. As far as subjects are concerned, 12 patients (14%) were over 50 years of age; 52 (64%) had GCS < 8, 39% of patients had polytrauma, 32% of which had pupillary abnormalities (anisocoria or mydriasis). Another factor was lack of ideal conditions for all patients. In this series, there were no beds in the ICU for 24 patients (27%) after surgery, and they remained in the post-anesthesia recovery room, without ICP monitoring. But of all these factors, the only one that was statistically related ($p<0.05$) to bad prognosis was GCS upon admittance, in agreement with other authors[3,4,11,14] .It is worth emphasizing characteristics of the hospital where the study was carried out (Hospital Pronto Socorro João XXIII), which is a reference center for trauma in Minas Gerais. Although is has a large number of ICU beds, there is always a larger number of patients in the polytrauma room. Many of the cases presented here could have been sent to the ICU where ICH would have probably been treated clinically. Because of the lack of treatment in the ICU before surgery, DC was performed preventively in some patients in order to save them, once they would remain in the polytrauma room without ICP monitoring or any clinical treatment of ICH. Such patients may have had a favorable outcome undergoing preventive DC because they had ICH that would have been controlled with clinical procedures.

Complications – This study found 34.8% of complications directly related to the proposed technique: hydrocephalus in 7 patients (7.9%); subdural effusions in 10 (11.3%) (Fig 2) and infection in 14 (15.9%). Among infection cases, four were meningitis, and the others were superficial. Polin et al. reported 28.5% of hydrocephalus[11]. Guerra et al. found subdural effusions in 26%, hydrocephalus in 14%, and infection in 2%[4].

There are no conclusive studies regarding pathophysiology and treatment of subdural effusions and hydrocephalus that occur after DC. In the series of 50 patients treated with DC for cerebral tumefaction, Aarabi et al. found 25% of subdural effusions[14]. Spontaneous resolution was reported in all cases. Bone resorption occurred in 6 cases

Fig 2. Subdural effusion on the left.

and bone flap infection in 3 patients. Doss et al. carried out a comparative study in 40 patients, separating them in two groups: early and late cranioplasty[16]. A larger number of complications related to CSF flow (hydrocephalus and subdural effusions) was found in the late cranioplasty group. An improvement after replacement of the bone flap was reported, which suggests that the placement of definitive shunt device should be delayed in such patients.

Most articles in foreign literature mention the bone bank (cryopreservation) as an option to store the bone flap removed during DC[2,3,4,11,14]. However, Grant et al. reported a high rate (50%) of symptomatic bone resorption (requiring another surgery) in 40 cases of children and teenagers submitted to DC with bone stored in the bone bank[17]. Other techniques can be associated to an even higher resorption rate such as autoclaving the bone, once denaturation of proteins responsible for bone growth occurs[18]. Missori et al. reported sterilization of bone flap with ethylene oxide[19]. Movassaghi et al. carried out a study specifically on this subject and found favorable outcomes storing the bone flap in the abdominal subcutaneous tissue in 53 pacientes[20]. In our study the bone flap was stores in the abdominal subcutaneous tissue in only 25 patients (33%). The others were discharged without bone flap replacement for subsequent heterologous cranioplasty (with acrylic).

Another factor that lacks definition in literature is the time required to perform cranioplasty after DC. One of the main recommendations for cranioplasty immediately after DC is protection of the underlying brain tissue and esthetics. Yamaura and Makino defined a clinical syndrome in patients with a large cranial bone defect called syndrome of the sinking flap[21]. Along with other studies, they noticed that these patients often had serious headache, vertigo, dizziness, fatigability, memory deficits, irritability, convulsions, depression and intolerance to vibration[21-23]. These studies also showed improvement in patients after bone flap replacement or heterologous cranioplasty was performed. Yamaura and Makino relate these deleterious effects to atmospheric pressure on the underlying brain tissue[21]. Winkler et al. demonstrated improvement in brain metabolism and CBF after cranioplasty in 13 patients, which suggests that early cranioplasty helps rehabilitation of such patients[24].

Literature does not offer a solution for the need of ICP monitoring after DC is performed. In this study post-operatory ICP monitoring was carried out in 51 patients. 26 patients (51%) had at least one episode of ICH (ICP >20 mm Hg), although it was not correlated as a determining factor for prognosis. This fact shows that over half of the patients who underwent DC can have post-operatory ICH episodes.

Prognostic factors – Age, anisocoria, polytrauma, tomographic findings and ICH have been reported as factors independent from prognosis[12,25-30]. In this study none of these factors was statistically correlated to prognosis ($p>0.05$).

GCS upon admittance proved to be an independent factor for prognosis ($p=0.0309$). Other studies also found this item as predictive prognosis[3,4,11,14]. Jennett and Teasdale reported that GCS, in spite of being a good indicator of trauma severity, can show external influences such as alcoholic intoxication and hemodynamic instability[30]. They suggested that this rating be performed within six hours of trauma. Traumatic Coma Data Bank suggests accepting the better GCS rating after clinical ressuscitation (volume and oxygen) of patient[12].

We came to the conclusion that GCS, in spite of being a good outcome predictor, is subject to changes during the trauma first hours. In this study the first GCS described upon admittance was considered by the assistant neurosurgeon, and it often reflected ratings reported by the rescue team. This must be taken into consideration while analyzing the results of this study.

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