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Decompressive craniectomy, interhemispheric hygroma and hydrocephalus: A timeline of events?

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ABSTRACT

Background: Decompressive craniectomy (DC) is a known risk factor for the development of post-traumatic hydrocephalus. The occurrence of subdural hygroma (SH) was also reported in 23–56% of patients after DC and it seemed to precede hydrocephalus in more than 80% of cases. We analyzed the relationship among DC, SH and hydrocephalus.

Methods: From 2007 to 2011, 64 patients underwent DC after head trauma. Variables we analyzed were: intaventricular hemorrhage, age, GCS, distance of craniectomy from the midline, evacuation of a hemorrhagic contusion (HC) and infection. Logistic regression was used to assess the independent contribution of the predictive factors to the development of hydrocephalus.

Results: Nineteen patients (29.7%) developed hydrocephalus. Interhemispheric SH was present in 8/19 patients with hydrocephalus and temporally preceded the occurrence of ventricular enlargement. Moreover, most patients who developed a interhemispheric SH had been undergone DC whose superior margin was close to the midline. Logistic regression analysis showed that craniectomy closer than 25 mm to the midline was the only factor independently associated with the development of hydrocephalus.

Conclusion: Craniectomy close to the midline can predispose patients to the development of hydrocephalus. SH could be generated with the same mechanism, and these three events could be correlated on a timeline.

1. Background

Decompressive craniectomy (DC) is a life-saving procedure performed in case of critically increased, not otherwise controllable intracranial pressure (ICP) after traumatic brain injury (TBI), in order to preserve the perfusion, oxygenation and compliance of the brain [1–5].

However, the complications related to this procedure may reduce its potential benefits [6].

After TBI, the occurrence of hydrocephalus is a well-known phenomenon, with a wide range of incidence among the reported series (0.7–86%), probably due to the different diagnostic criteria [6–12].

After DC, in particular, several factors have been associated with the development of communicating hydrocephalus, such as older age, subarachnoid hemorrhage, cerebrospinal fluid (CSF) infection, lower Glasgow Coma Scale (GCS) and wide craniectomic flap [6,8,13–16]. In a previous paper, we reported that craniectomy with a superior limit closer than 25 mm to the midline might predispose to the development of hydrocephalus as well [17].

Also the occurrence of subdural hygroma (SH) has been frequently (23–56%) reported after DC [2,18–20]. It has been observed ipsi- or contralateral to the side of the craniectomy (sometimes bilaterally) or in the interhemispheric space [4,21].

Kaen et al. reported occurrence of hydrocephalus in 27.4% of patients with severe TBI who underwent DC. They found that interhemispheric SH preceded hydrocephalus in more than 80% of cases and it was the only independent prognostic factor associated with the development of post-traumatic hydrocephalus [4]. Recently, Honeybul and Ho also showed that the presence of SH as well as a higher ICP prior to decompression and a lower admission GCS score were independent risk factors for developing hydrocephalus after DC [20].

Furthermore, Aarabi et al. observed in their series that most of the patients who exhibited interemispheric SH after DC also had undergone evacuation of hemorrhagic foci [2]. Based on this evidence, Takeuchi et al. hypothesized that the amount of volume

Abbreviations: DC, decompressive craniectomy; GCS, Glasgow Coma Scale; ICP, intracranial pressure; TBI, traumatic brain injury; CSF, cerebrospinal fluid; SH, subdural hygroma; HC, hemorrhagic contusions.

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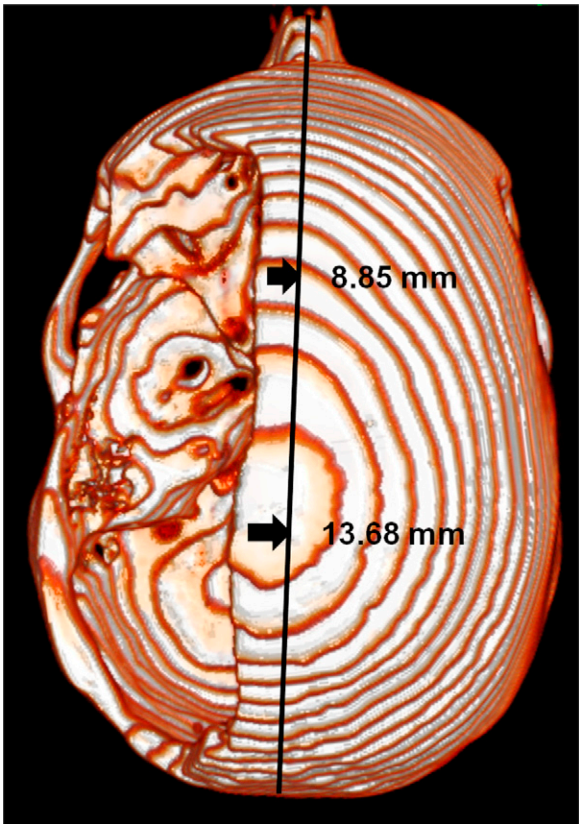

Fig. 1. CT scan: 3D reconstruction. This patient underwent a left hemispheric DC. The distance from the midline is shown.

removed at surgery could be correlated with the occurrence of interhemispheric SH [22].

In order to improve the understanding of a potential relationship among DC, SH and post-traumatic hydrocephalus, we performed a retrospective review of the neuroradiological and clinical features of a consecutive series of patients undergoing DC after TBI.

2. Methods

From January 2007 to December 2011, 64 patients underwent DC for the treatment of otherwise uncontrollable intracranial pressure after closed TBI. Thirty-one of these 64 patients have already been analyzed in a previous study [17]. The criteria for DC used in our institution have been previously described [17,23]. DC was performed through the removal of a wide fronto-temporo-parietal bone flap until the level of the zygoma (Fig. 1), followed by expansive duraplasty [17,23].

For all patients, clinical and demographic characteristics as age, sex, GCS after resuscitation and CSF infection during hospitalization, were recorded. Moreover, all available serial CT-scans from admission to discharge were evaluated in order to search for hydrocephalus, intraventricular hemorrhage, intraparenchymal hematomas or hemorrhagic contusions (HC), convexity and interhemispheric SH and to measure the distance of the craniectomy from the midline.

Post-traumatic hydrocephalus was defined as radiographic evidence of progressive ventricular dilatation with an Evan's index > 0.3, associated with narrowed CSF spaces at the convexity on CT imaging [24,25]. For patients with poor neurological status at baseline, clinical examination results were not included as a defining element in the determination of hydrocephalus. For patients showing an initial improvement of clinical condition, an impaired consciousness or a worsening neurologic status (not due to infections or other medical causes), this was included as a defining element in the determination of hydrocephalus. ICP measurement was instead not included in this definition. The distance of craniectomy from the midline was calculated through the analysis of 3D reconstructions from CT scan images (Fig. 1).

2.1. Statistical analysis

Study outcome focused specifically on the development of hydrocephalus after DC. The outcome was dichotomous (hydrocephalus vs no hydrocephalus). The statistical package used for the analyses was SPSS for Windows version 13.0 (SPSS Inc., Chicago, IL). The Fisher's exact test was used for univariate analysis. Variables we analyzed were: presence of intraventricular hemorrhage, age (as a continuous variable), post-resuscitation GCS, distance of craniectomy from the midline, presence of interhemispheric or convexity SH, HC evacuation and infection. The quartiles of the distribution of the variable "distance of craniectomy from midline" were obtained and a categorical variable with 4 levels using three cut-points based on the quartiles was created. Variables with a $p < .2$ at univariate analyses were considered for multivariate analysis. Logistic regression model was used for multivariate analysis in order to assess the independent contributions of the predictive factors to the development of hydrocephalus. The association between the variables was considered to be significant when the p value was less than .05.

3. Results

The study population consisted of 64 patients (51 males, 13 females; age range 16–80 years; mean age 37.9 ± 21.9 years). Patients' characteristics are shown in Table 1.

A significant reduction in mean ICP was obtained for all patients after surgery (from 31 ± 5 mmHg to 14 ± 7 mmHg at 48 h postoperatively). Nineteen patients (29.7%) developed post-operative hydrocephalus. All of these patients presented with progressive ventricular enlargement both before and after cranioplasty and underwent CSF diversion after cranioplasty. A SH (convexity and/or interhemispheric) was overall present in 36 patients (56.2%). An interhemispheric SH was present in 8/19 patients (42.1%) with hydrocephalus and in 8/45 patients without hydrocephalus (18%) – Fig. 2.

At univariate analyses, intraventricular hemorrhage, SH at the convexity and SH of any type (convexity + interhemispheric) were not significantly associated with the development of hydrocephalus.

Out of the 19 patients who developed hydrocephalus, 15 patients (79%) had been undergone craniectomy whose superior limit was ≤25 mm from the midline (median value) and this association was statistically significant (Fisher's exact test: 2-sided $p < .0001$). The association between the presence of an interhemispheric SH and hydrocephalus showed a trend toward significance (Fisher's exact test: 2-sided $p = .058$).

Only 3 out of 64 patients (4.7%) suffered from CSF infection prior to cranioplasty, and all of them developed hydrocephalus after resolution of the infection (Fisher's exact test: 2-sided $p = .02$ – Table 1). Due to the small number of patients, this variable was not included in the multivariate model.

A significant relationship was observed between the superior limit of the craniectomy ≤25 mm from the midline and interhemispheric SH development (Fisher's exact test: 2-sided $p = .05$). The association between the interhemispheric SH appearance and HC evacuation was not statistically significant (Fisher's exact test: 2-sided $p = 1$ – Table 2).