# CONSIDERATION ON HEMICRANIECTOMY

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Decompressive hemicraniectomy is a surgical technique used to relieve the increased intracranial pressure. There is no standardized surgical technique to clearly state the minimum area of the cranial vault needed to obtain the best results. The aim of the current paper is to present our surgical technique and experience used in performing hemicraniectomies, technique that we consider optimal for his purpose. Our experience consists in 17 operated cases and eleven patients (64,7%) were long term survivors.

Keywords: cerebral edema, decompressive hemicraniectomy, malignant cerebral infarction, traumatic head injuries

## INTRODUCTION

Decompressive hemicraniectomy is a surgical technique used to relieve the increased intracranial pressure. Benefits from hemicraniectomy was reported in ischemic stroke, central venous thrombosis, intracerebral hematoma, head injuries (especially acute subdural hematoma), encephalitis, subdural empiema, aneurismal subarachnoid hemorrhage and even in other rare clinical situations such as Reye's syndrome or hepatic failure (7,9). The common pathological aspects of this disease are massive brain swelling with increased intracranial pressure. The overall goal of hemicraniectomy is to increase the volume-buffering capacity of the cranial vault, allowing for centripetal herniation, minimizing centrifugal compression of brain stem structures (9).

From historical point of view, cases of hemicraniectomy date back as far as the late 1800s, but the procedure was first described in 1905 by Harvey Cushing (1,2).

However the term "hemicraniectomy" is frequently derisory and wrongly used for any operations involving a large cranial vault followed by removal of the bone for permitting the brain to enlarge. There is no standardized surgical technique to clearly state the minimum area of the cranial vault needed to obtain the best results. The aim of the current paper is to present our surgical technique and experience used in performing hemicraniectomies, technique that we consider optimal for his purpose. Also, we discuss the opportunity of these "saving lifes" operations and the way a satisfactory functional and esthetical recovery occurs.

## MATERIAL AND METHODS

Our experience consists in 17 cases operated by the author in Cluj-Napoca Neurosurgical Clinic, Romania, between January 2002 and January 2008 (table 1). Malignant cerebral infarction count for 7 cases (41,2%), traumatic head injuries count for 9 cases (52,9%), and encephalitis with subdural empiema for one case (5,9%). The same standard surgical procedure was preformed for each of the patients. Bifrontal decompressive craniectomies were not included.

The indications for hemicraniectomy were based on these head CT-scan characteristics: massive cerebral edema with midline shift (more than 1 cm) with

disappearance of basal cisterns, correlated with clinical state at admission and neurological evolution of the patients. For malignant cerebral infarction with clear CT criteria, the surgery is indicated before the patient becomes comatose. In posttraumatic hematomas or epidural empiemas with encephalitis, we compare the mass effect on CT with the thickness of the hematoma. Hemicraniectomy was preformatted when a large discrepancy of the mass effect was found, even if the patients already develop sign of brain herniation (uncal or subfalxial herniation).

## SURGICAL TECHNIQUE CONSIDERATIONS:

The patient is placed with the side of craniotomy upward, head elevated to 15 degree. The line of skin incision is described from posterior to anterior: beginning retro-auricular (to the mastoid), extended in a supero-posterior manner and than reversed to anterior approximately 2 cm parallel to the sagittal line until the widow peak, then reversed infero-basal, respecting the hair line to the preauricular region. Care must be taken to preserve the principal ramifications of temporary artery inside de musculocutaneous flaps. The temporalis muscle is reflected basally. The margins and burrholes for hemicraniectomy, described from anterobasal to posterior are: temporo-basal, under the level of ear pina; pterional at the site of the classic keyhole; fronto-basal, above the level of frontal sinus, to expose frontal pole but avoid entry in the frontal air cells sinus; then along the planned paramedial craniectomy margin, 2 cm parasagittal (avoid lesions over saggital sinus and bridging veins), until lambda point; then antero-basal, tangent with lambdoid suture, until 1 cm above the asterion (to avoid lacerations of transverse-sigmoid sinus). The sphenoid wing is fractured and removed. Decompression was extended far enough to the floor of the middle fossa to relieve pressure from the herniating mediobasal temporal lobe and up to the midline to avoid compression of the bridging veins (1-2 cm) (10). The dura is opened by a large radial incision to allow the brain to expand outward (11). Prophylactic, if the intracranial pressure is not elevated, dural edges are tacked up to bony margins. Large duraplasty with extra space for brain to enlarge, using all periostal tissue from the cranial vault is performed.

## RESULTS

Eleven from 17 patients (64,7%) were long term survivors. Six patients (35,3%) died in the first 3 weeks postoperatively. Male gender was predominant (65%). Median age was 46,8 years for the survivals patients and 60,3 years for the group of deceased patients.

In the stroke group median age was 56,7 years. Male gender represented 57,1%. Right hemisphere was affected in 71,43% of cases. Four patients out of 7 (57,1%) were long term survivors (42,9% mortality in stroke group). Over 70% of the patients were progressively somnolent, presenting intracranial hypertension and hemiparesis on admission. Only 20% of these (representing 1 case who died at 2 weeks postoperative by pulmonary trombembolism) died postoperatory. All patients admitted in coma state (30%) died postoperatory.

From the deceased patients in the stroke group, 2 died from pulmonary complications and only one by general state deterioration determined by cerebral herniation. Sixty-seven percent (2 cases) from these were admitted in comatous state.

In posttraumatic lesions, the group's median age was 48 years. Male gender was predominant (88,9%). The right hemisphere was affected in 86,41% of cases. Six patients from 9 (66,7%) were long term survivors (33,3% mortality in posttraumatic group). All the patients with posttraumatic lesions at admission were in medium or high grade coma scale. Two patients died by general state deterioration determinated by cerebral herniation and one patient from pulmonary complications. From the deceased patients 66,7% were admitted in grade IV coma state.

Long term neurological recovery was excellent especially in the cases of posttraumatic lesion. Cranioplasty with self bone kept in abdominal fat (placed in right abdominal subcutaneous fat at the time of hemicraniectomy) was made initially in 7 cases (41,2%). The majority of grafts showed some degree of degeneration. Two of these cases (28,6%) were complicated by infection and the bone was removed.

After the infection was cured, cranioplasty with custom-made plate was performed. In other two cases direct custom-made cranioplasty was preformed with no complications. Silicone rubber mould cast polyethylmethacrylate-hidroxyapatite plate manufractured using rapid prototyping techniques offered us the maximum functional and esthetical recovery (12, 13). We use it now as primary intention technique for large cranioplasty.

## DISCUSSIONS

Hemicraniectomy versus medical care.

Established clinical trials and retrospective study for malignant cerebral infarction show a reduced mortality at hemicraniectomisated patients from 75-80% to 24-30%. (5,6,9) Much more, the mortality can be further reduced with 10% by undertaking decompression within 24 hours of ictus. (9)

In the cases of traumatic hematomas, Whitefied and colleagues found in a series of 26 patients the following results: 61% of the patients who underwent decompressive craniectomy attained favorable outcome, compared with 30% in the control group. Other recent studies suggest that young patients with GCS greater than 4 may benefit from decompression when the intervention is performed early.

Young age is a frequently discussed factor for a good outcome for hemicraniectomisated patients. In our study the median age was 46,8 years for the survivors and 60,3 years for the group of deceased patients.

## SURGICAL INDICATIONS CRITERIA

For the patients with ischemic stroke, CT related criteria for hemicraniectomy are: massive cerebral edema with deviation of the midline shift (more than 1 cm) and lack of basal cisterns. Neurological deterioration and cerebral edema are installing progressively in 24-72 hours. CT aspects are also variable during this interval: after 24 hours from stroke, hipodensity of the infracted area may be seen; malignant cerebral edema usually appear only 48 hours after the initial event. However, CT criteria must be correlated with the clinical state at admission and neurological evolution of the patients. If the patient is already in a coma, we think that no good results will be achieved, and the patients have no indication for operation. In our study the mortality was significantly higher in the group admitted in comatous state (100% mortality) compared with the patients who were only somnolent or presenting sign of intracranial hypertension and hemiparesis (20% mortality, representing 1 case who decedate at 2 weeks postoperative by pulmonary trombembolism). These proves there is no need to wait for the patient to become comatose to perform a hemicraniectomy.

This is not the case with posttraumatic supraacute epi/subdural hematomas, were life of a high grade coma patient, even with pupillary inequality or recent installed bilateral midriasis, may still be saved by a heroical intervention. In posttraumatic hematomas (with or without subjacent cerebral contusion) and also in epidural empiema with encephalitis, for hemicraniectomy to be indicated the mass effect should be larger than the thickness of hematoma. These make all the difference between the need of hemicraniectomy and the need of a classic cranial vault for evacuation of intracranial collection.

Although the mortality rate probably will fall after decompressive surgery, it is unclear which groups of patients benefit most from the procedure (4). This type of surgical intervention was wrongly reserved especially for the most critical cases, admitted in high grade coma scale, frequently with constituted neurological sign of cerebral herniation. These cases have anyway a poor outcome, determinates by the advanced of cerebral herniation and the general deterioration. Also, frequently these patients, after survival from the postoperative state, remain in vegetative state for a long period of time, dying lastly from bronhopulmonary or systemic complications. In either of the cases, the outcome of these patients was very poor, wrongly inducing the idea that hemicraniectomy is an hopeless operations. The good operative indications, applications of the standardised large hemicraniectomy and favorable evolutions of intensive medical care for comatose patients, will increase the real chances of survival for this patients, reveling finally the importance of this surgical procedure.

Hemicraniectomy versus other types of decompressive vaults. (or "How large should the extension of bone removal be?")

The magnitude of intracranial cerebral pressure reduction correlates with the size of craniectomy and ranges from 15-85%. Durotomy further enhances the release of cerebral pressure (9). The need for a radical approach (in terms of extension of bone removal) was recognized by Kerr in 1968 in the event of severe posttraumatic cerebral edema. His observation was echoed in the case of massive cerebral ischemia by Rieke who found that a few of their initial surgically treated patients harbored a bone defect that was too small, not providing adequate space for decompression and resulting in brain herniation through the skull opening (8). Wirtz reveal that an exponential relationship between craniotomy size and gained volume for brain to enlarge. Until 6 cm diameter of the cranial vault the decompression is not significant. To obtain a 50 ml gained volume, craniotomy size must have at least 10 cm in diameter (10,11). The real increase in decompression volume is obtained from 12 cm, witch correspond to much over 100 ml buffering volume. To every centimeter in plus over 12 cm, an additional increase of decompression volume of approximately 50 cc is obtained (10). In another study regarding surviving patients, the mean distance to the temporal skull base was less (1.7 ± 1.2 cm) than for those who did not survive (2.3 ± 1.3 cm)(10).

## CONCLUSIONS

Best result in surgical treatment of malignant cerebral edema caused by a variability of pathological lesions (especially malignant cerebral ischemia and supraacute convexital subdural hematoma) depends principally by three thinks: good operative indications, applications of the standardisated large hemicraniectomy and best intensive medical care for these patients.

A large hemicraniectomy presumes that the craniotomy vault should have at least 10-12 cm diameter. Until 6 cm diameter of the cranial vault the decompression is not significant.

Good operative indication is based on the CT criteria and clinical state at admission. These make that the operative indication to be different for the principal malignant edema condition. For post ischemic edema CT criteria are massive cerebral edema with deviation of the midline shift and disparities of basal cisterns. From clinically point of view, there are no needs to wait that the patients become comatose to perform a hemicraniectomy. We can anticipate his evolution based on CT aspects and knowledge of natural evolution of the ischemic stroke. Patients with ischemic stroke presented in coma state have no benefit from hemicraniectomy. In posttraumatic hematomas and epidural empiema with encephalitis, for the hemicraniectomy to be indicated, mass effect must be large compared with the thickness of hematoma. For this cases, good result can be obtained by a ultra rapid operation despite clinical condition.

| Nr | Age | Sex | Diagnose | Admision state | Cranioplasty | Complicaions and postoperative evolutions |
|---|---|---|---|---|---|---|
| 1 | 61 | F | Right MCAT | Coma grd.III | - | Dead at 11 days postop. by general state deteriorations determinate by post cerebral herniation. |
| 2 | 47 | F | Right ICT | Somnolent ICH Hemiparesis | At 6 months with self bone kept in abdominal fat | No complications |
| 3 | 53 | M | Right ICT | Somnolent ICH Hemiparesis | At 12 months with custom-made plate. | No complications |
| 4 | 46 | M | Right ICT | Somnolent ICH Hemiparesis | At 6 months with self bone kept in abdominal fat. | No complications |
| 5 | 67 | M | Right MCAI | Somnolent ICH Hemiparesis | - | Dead at 1 week postop. by pulmonary trombembolism. |

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|---|---|---|---|---|---|---|
| 6 | 64 | F | Left MCAT | Coma grd.II | - | Dead at 2 weeks postop. by pulmonary complications. |
| 7 | 59 | M | Hemoragic stroke | Somnolent ICH Hemiparesis | At 2 months with self bone kept in abdominal fat. | Infection of bone with Staphilococus Aureus. Target antibiotherapy with Vancomicine was made. The bone was removed at 2 months after the cranioplasty. After the infections was cured, cranioplasty with custom-made plate was made. |

| Nr | Age | Sex | Diagnose | Admision state | Cranioplasty | Complicaions and postoperative evolutions |
|---|---|---|---|---|---|---|
| 8 | 61 | M | Right convexital posttraumatic SDH | Coma grd. II | At 6 months with self bone kept in abdominal fat. | No complications |
| 9 | 37 | M | Right convexital posttraumatic SDH | Coma grd. III | At 6 months with self bone kept in abdominal fat. | No complications |
| 10 | 21 | M | Right convexital posttraumatic SDH | Coma grd.III | - | No complications |
| 11 | 45 | F | Right convexital posttraumatic SDH | Coma grd.IV | - | Dead at 2 weeks postop. by general state deteriorations determinate by post cerebral herniation. |
| 12 | 23 | M | Left convexital posttraumatic SDH. | Coma grd. III with papillary asymmetry | At 2 months with his own cranial vault kept in abdominal fat. | Infection of cranioplasty bone. The bone was removed and at 6 months after the infection was cured cranioplasty with custom-made plate. |
| 13 | 67 | M | Left convexital posttraumatic SDH. | Coma grd.II | - At 6 months with self bone kept in abdominal fat. | |
| 14 | 70 | M | Posttraumatic hemorrhagic contusions, SAH | Coma grd.III | - | Dead at 2 weeks postop. by pulmonary complications. |
| 15 | 53 | M | Right convexital posttraumatic SDH | Coma grd.III | At 12 months with custom-made plate. | No complications. |
| 16 | 55 | M | Right convexital posttraumatic SDH | Coma grd. IV | - | Dead at 2 weeks postop. by general state deteriorations determinate by post cerebral herniation. |
| 17 | 48 | M | Epidural empiema with cerebral encephalitis. | Somnolent ICH Hemiparesis | At 12 months with custom-made plate. | No complications. |

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