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Role and Assessment of Outcome of Decompressive Craniectomy in Malignant Middle Cerebral Artery Infarction in Patients: A Hospital Based Retrospective Study

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Abstract
Objective: *Malignant middle cerebral artery (MCA) infarction is characterized by mortality rate of up to 80%.*
Aim: *To determine the role of decompressive craniectomy in patients presenting malignant MCA infarction ant to assess its outcome in patients.*
Material and Method: *This retrospective study included a sample of 25 patients with malignant MCA infarction who underwent decompressive craniectomy in the Department of Neurology at Geetanjali Medical College and Hospital during the period of 1st January 2016 – 31st January 2017. Clinical characteristics included preoperative clinical condition, timing of surgery, cause of infarction, location, and extension of infarction was analyzed. In addition, the time delay from the onset of symptoms to surgery and preoperative signs of herniation and their relation to the final outcome was analyzed. The final outcome was assessed in terms of mortality and scores such as modified Rankin scale (mRS). Functional outcome was divided into two groups: Favorable outcome (mRS score 0–3) versus poor outcome (mRS score 4–6).*
Result: *25 patients of age between 21 and 80 years with mean age of 53.96 ± 10.09 years were analyzed. 64% of the patients were of age below 60 years. 48% patients were operated within 48 hours and 52% were operated after 48 hrs. mRS between 0-3 was observed at discharge in both which was not statistically significant. But according to age, 33.33% patients with age more than 60 years and 81.25% patients with age less than 60 years had mRS 0-3 which was statistically significant.*
Conclusion: *Decompressive craniectomy in malignant cerebral artery infraction had reduced the mortality especially in patients of age less than 60 years and those who operated within 48 hours of stroke. Thus there is no reason to deny the surgery.*
Keywords: *Decompressive craniectomy, malignant, infraction, modified Rankin Score, Glasgow coma scale.*

Introduction

Decompressive craniectomy is a surgical treatment for brain edema which has been performed for many years and for several different pathophysiologies including traumatic brain injury and non-traumatic brain injury.

Among cases of supratentorial infarction, 10–15% involves the entire MCA territory.[1,2,3,4] Despite optimal medical therapy, the mortality rate approaches 80%. This type of extensive stroke has been termed malignant MCA infarction and is accompanied by severe brain edema, leading to raised ICP and subsequent brain herniation.[5] A vicious cycle develops as the resulting ischemic insult leads to further edema, and thus to increases in ICP and reduction of regional cerebral blood

flow.[6] Medical treatment has not been shown to be effective.[7]

Several experimental studies [8, 9] have shown the benefit of decompressive craniectomy in rats after MCA occlusion. In these studies, craniectomy resulted in improved outcome, and, if treated early enough, reduced infarction size. In 1956, Scarcella [10] first described the surgical removal of a large bone flap with duraplasty ipsilateral to the infarction to reduce ICP and prevent brain herniation. Since then, there have been several case series and reports indicating improved survival and functional outcome. Three randomized controlled trials were performed to study the effects of Decompressive craniectomy after malignant stroke.[11, 12, 13] The pooled analysis of these trials confirmed the suggestions from nonrandomized studies that Decompressive craniectomy undertaken within 48 hours of stroke onset reduces mortality rates and increases the number of patients with a favorable functional outcome after malignant hemispheric infarction.[13]

Methods

For the study, 25 patients with malignant MCA infarction who were treated at Department of Neurology, Geetanjali Medical College and Hospital, Udaipur during the period of 1st January 2016 to 31st January 2017 were taken.

Inclusion criteria

1. Infarction of more than 50% of the MCA territory as defined by computed tomography (CT) and/or magnetic resonance imaging (MRI) with an acute onset of corresponding clinical signs and symptoms
2. Neuroradiological evidence of local brain swelling such as midline shift of 5 mm or more indicating space occupying edema.

Exclusion criteria

1. Patients with small size infarctions, as they usually were treated successfully by conservative methods.

Decompressive craniectomy of all patients was done in case of significant neurological deterioration and informed consent obtained from the patients' relatives.

Clinical characteristics included preoperative clinical condition, timing of surgery, cause, location, and extension of infarction. In addition, the time delay from the onset of symptoms to surgery and preoperative signs of herniation and their relation to the final outcome was analyzed. The final outcome was assessed in terms of mortality and scores such as modified Rankin scale (mRS). Functional outcome was divided into two groups: Favorable outcome (mRS score 0–3) versus poor outcome (mRS score 4–6).

On admission, cerebral pathology was revealed by neuroradiological studies (computed tomography [CT]/magnetic resonance imaging [MRI]). The presence of a midline shift was measured by observation of the distance of septum pellucidum that deviated from the line between anterior and posterior falx cerebri at its attachment to the inside of the calvarium. The eligibility criteria for determining for carrying out decompressive craniectomy in malignant MCA infarction in our study were large MCA infarct defined as an ischemic lesion volume >150 cm^3 on diffusion-weighted MRI or CT evidence of at least >50% MCA territory infarction by visual inspection, clinical or radiological evidence of herniation and decrease in level of consciousness to a score 1 or greater on item 1a of the National Institute of Health Stroke Scale. Patients with Glasgow coma scale (GCS) <4, coma with two dilated pupil and absent brainstem reflexes were excluded from the study.

Each patient was fully resuscitated, investigated, and treated in Intensive Care Unit after first admission. Basic monitoring, frequent blood gas analyses, and all basic blood biochemistry parameters were followed twice daily. Neurologic monitoring included repeated monitoring of pupil size and its reactivity to light and periodic recording of the GCS score when possible.

Decompressions were performed using wide Fronto-Temporo-Parietal skin flap. The burr holes were connected using an electrical drill, with subsequent removal of a 12 cm × 15 cm free bone flap on affected side. The dura was usually opened with a C-shape incision in the areas involving the

frontal, temporal and parietal lobes extensively. Cortical resection was not performed in any patients. After duraplasty using pericranial patch graft, the temporal muscle was loosely re-approximated to the dura and the skin flap was then closed in two layers. The bone flap was usually re-implanted within 6–12 weeks after craniectomy.

Mortality rates and outcome scores were assessed. Rates were compared using the Fisher exact test, and p values < 0.05 were considered statistically significant.

Result

In the study total of 25 patients with malignant cerebral artery infraction were included who underwent Decompressive craniectomy. Data collection was done between the period of January 2016 – January 2017. In this study, minimum and maximum age of the patient was found to be 21 and 80 years respectively. Mean age of patients was observed to be 48.1 ± 15.08. Mean age of male and female patient found to be 47.56 ± 15.6 and 49.25 ± 14.6 respectively, and it was observed that there is no significant difference regarding the age. The study group consists of 17 males and 8 females. Out of total patients, majority of the patients i.e. 16 (64%) found were below the age of 60 years and remaining 9 (36%) patients were below age of 60 years. Table 1

18 patients had right sided stroke and only 7 had left sided stroke. Table 2

Out of 25 total subjects, 96% were suffering from Hypertension, 52% with preexisting Diabetes and 33% patients had suffered from coronary artery diseases. Only 1 patient out of 25 was found who had Chronic Renal failure before surgery. Table 3

Mean GCS score of the patients at the time of presentation was 11.34 ± 3.1 and 7.01 ± 1.6 at time of surgery. This was found to be statistically significant difference. Table 4

According to Modified Rankin Scale (MRS) all the patients had poor outcome. 24 patients found to have MRS of 4 at surgery and 1 patient had MRS of 6 at surgery. This shows no patients had favorable outcome according to GCS score. The number of patients who operated before the period of 48 hours was found to be 12 out of 25 (48%) and remaining 13 (52%) patients were operated after 48 hours. Out of 13 patients who operated after 48 hours of stroke, 6 patients were treated in the period of 48-96 hrs whereas and remaining 7 patients were treated after 96 hours. Out of those 12 patients, those who were operated before the period of 48 hours were observed to have favorable outcome according to GCS whereas comparative to this only 7 out of 13 (53.85%) patients, who were operated after 48 hours had favorable score at discharge. But this difference found to be statistically insignificant. Table 5

Out of 16 patients, 81.25% (13 out of 16) patients were below age of 60 years found to have favorable outcome and only 33.33% (3 out of 9) patients who were above age of 60 years had favorable outcome as per mRS. This was found to statistically significant. Table 6

At the time of discharge mean score of patients according to MRS was 3.2 which shows poor outcome. 32% patients with age less than 60 had lesser complication as compared to 36% patients with age of more than 60 years. This difference was found to be statistically insignificant.

In this study not a single patients was found with cerebrospinal, fluid leakage, intracranial and/or wound infection. Only 4% mortality was observed in this study.

Only one male patient of age 51 years died during the stay is hospital in postoperative. The GCS at the time of surgery was 5 and was on ventilator during hospital stay.

1 male and 1 female patient was discharged against the advice of doctor as their family was not willing to continue the treatment due social and economic reasons.

Overall it was observed in this study, that preexisting disease, which is predictors of poor survival; do not significantly influence the mortality and functional outcome. The reason for observation may be small subjects for the study and is considered as the major limitation of this study.

Table 1

Age group	Male	Female	Total
21-30	2 (11.76%)	0	2 (8%)
31-40	2 (11.76%)	2 (25%)	4 (16%)
41-50	3 (17.65%)	1 (12.5%)	4 (16%)
51-60	4 (23.53%)	2 (25%)	6 (24%)
61-70	4 (23.53%)	2 (25%)	6 (24%)
71-80	2 (11.76%)	1 (12.5%)	3 (12%)
Total	17 (100%)	8 (100%)	25 (100%)

Table 2

Side of stroke	Number of patients	Percentage
Right	18	72%
Left	7	28%
Total	25	100%

Table 3

Pre existing disease	Number of patients (n = 25)	Percentage
Hypertension	24	96%
Diabetes	13	52%
Coronary Artery failure	8	32%
Chronic Renal failure	1	4%

Table 4

GCS score	Mean ± SD	t value	P value
At presentation	11.34 ± 3.1	6.206	<0.001*
At surgery	7.01 ± 1.6		

Table 5

Time of operation		Number of patients (n = 25)	Favorable outcome (n = 25)	Poor outcome (n = 25)
Within 48 hrs		12 (48%)	9 (72%)	3 (12%)
After 48 hrs		13 (52%)	7 (28%)	6 (24%)
	48-96 hrs	6 (24%)	5 (20%)	1 (4%)
	After 96 hrs	7 (28%)	2 (8%)	5 (20%)

Table 6

	AGE		Test values	P value
	Less than 60 yrs (N = 16)	More than 60 yrs (N = 9)		
Favorable outcome (mRS)	13 (81.25%)	3 (33.33%)	Z value = 1.962	0.05*
Number of days on ventilator (mean ± SD)	5.5±1.06	7±2.01	t- value = 2.462	0.022*
Complications	6 (37.5%)	4 (44.4%)	Z value = 0.087	0.930

Discussion

Malignant MCA infarction refers to life-threatening cerebral edema due to ischemic lesion volume >150 cm^3 or >50% MCA territory infarction. Malignant MCA infarcts accounts for 10% of supratentorial strokes and clinical worsening occurs in first 24–48 h. Malignant MCA infarction is so-called because of the secondary swelling that occurs in many young patients, and the mortality approaches 80%.

There is the limited role of conventional therapies such as mechanical ventilation, osmotherapy, hypothermia, and barbiturate administration in stroke patients developing intracranial hypertension.[14]

Malignant sylvian stroke is the only class I indication for decompressive craniectomy in people less than 60 old, but there are controversies.[15]Decompressive craniectomy interrupts the vicious cycle of extensive edema and elevated ICP to prevent further ischemia. Surgical intervention reduces initial elevated IC*P* value of by 15% and further reduction up to 70% occurs once the dura was opened. A craniectomy 8 cm large would appear large enough, but it gives just 23 ml additional volume. To obtain real decompression, a minimum diameter of 12 cm of Fronto-Temporo-Parietal bone or more gives 86 ml additional volume.

Decompressive craniectomy converts the closed, rigid cranial vault, into an open box which causes a dramatic decrease in ICP with reversal of the clinical and radiological signs of herniation. Early decompressive craniectomy can limit the spread of the infarcted area. The additional volume obtained by decompressive craniectomy is consequently superior to the one obtained by hyperventilation (2 ml/mm of lowering pCo2) and ventricular tap of 20–30 ml and is without the risk of loop diuretics.

Cerebral blood flow is increased in the decompressed brain within 24 h after decompressive craniectomy. There is increased brain swelling during the 1st week; which is most probably due to loss of resistance in the brain underlying the craniectomy, which would lead to increased transcapillary leakage due to a higher transcapillary hydrostatic pressure gradient.[16]

Several studies have reported an improved outcome in patients presenting with complete MCA infarction treated by decompressive hemicraniectomy. Studies indicate that during past four decades, the incidence of major disability or vegetative state has remained relatively constant,

although there has been a gradual decrease in the mortality rate and an increase in the proportion of patients with good outcome.[17]

Clinical effectiveness of Decompressive craniectomy in malignant MCA infarction for patients under the age of 50 years was demonstrated by three randomized, controlled trials (decimal, hamlet and destiny), and a pooled analysis of all three studies. Trials demonstrated reduction in mortality rate by 49% at 1-year after stroke undergoing decompressive craniectomy when compared with conservative care at the same time and mortality rate can be reduced to 20% with timely decompressive craniectomy-number needed to treat to prevent one death is only two. And the favorable functional outcome (0–3 in mRS) increased by 22% due to surgery (43% in the craniectomy group, 21% in the conservative care group).[18] In our study, 66% patients had the favorable outcome (mRS 0–3) at discharge which is much higher than reported in previous studies.

There are little data regarding the efficacy of surgery outside 48 h or in older patients. Approximately, 74% patients operated within 48 h had good recovery (mRS 0–3) at discharge while 56% patients operated after 48 h had mRS 0–3 at discharge. But this was not statistically significant. In contrast to previous studies, patients operated outside 48 h also fared well though number of patients with good recovery was not as good as operated within 48 h.

About 81.25% patients aged below 60 years had good recovery (mRS 0–3) at discharge while only 33% patients aged above 60 years had good recovery (mRS 0–3) at discharge which was statistically significant ($P < 0.006$). This is in concordance with previous studies which have also reported the poor neurological outcome in patients aged more than 60 years. 72% patients with right-sided stroke had good recovery (mRS 0–3) at discharge while 51% patients with left-sided stroke had good recovery (mRS 0–3) at discharge but difference was not significant statistically. Of one death, patient had left sided stroke.

One patient died during hospital stay, but we propose factors other than age like co-existing morbidity may play a role in mortality. The patient had preexisting diabetes and hypertension and had a history of coronary artery disease. Patients aged more than 60 years took more time to wean off the ventilator but the difference was not significant statistically.

Two patients were discharged against medical advice due to social and financial constraints but there was no statistically significant difference in terms of age, time to surgery since onset of stroke, co-morbidities and preoperative and postoperative neurological status as compared to rest of the group.

The risk of fatal complications such as intracranial infections and contralateral intracerebral hematoma exist but rarely take place. Other complications (such as subdural effusion-hygroma, posttraumatic hydrocephalus, epilepsy) can adversely affect the patient's outcome.[19]None of our patient had a complication directly related to surgery. Complications during hospital stay like sepsis, bedsore, ventilator acquired pneumonia, and deep vein thrombosis were more common in patients aged more than 60 years but was not significant statistically.

In decompressive craniectomy, there for few key questions which always hammer treating neurologist and neurosurgeon while considering patients who need this life-saving procedure that whether decompressive craniectomy really saves life and improves neurological outcome. Decompressive craniectomy no doubt reduces mortality and increases the proportion of patient with good recovery but also there is a subset of patients who survive but lead bedridden life.

Conclusion

Decompressive craniectomy has reduced morbidity and mortality especially in people aged below 60 years and those operated within 48 hours of malignant MCA stroke though those operated outside 48 hours of stroke also fare well neurologically. Therefore, patients should not have any reason to deny surgery. Patient and their

family should be approached with extreme honesty, objectivity, and humility during discussing about decompressive craniectomy.

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