



Outcome of decompressive craniotomy in malignant middle cerebral artery infarction: a retrospective study.

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Abstract

Malignant middle cerebral artery (MCA) infarction, caused by complete Middle cerebral artery occlusion, produces extensive cerebral edema, which causes rapid neurological deterioration. Though the incidence of this entity is 1-10% of all MCA territory infarcts, it has a high mortality of up to 80%. Decompressive craniotomy, as a measure to combat the edema, is an established procedure. In this ten-year retrospective study, we performed decompressive craniotomy, as a lifesaving procedure, in 86 selected patients, under 65 years of age, diagnosed with malignant MCA infarction, and compared our results with 68 patients, of the same age group, treated solely on medical therapy. 92 patients were excluded from this study for age>65 years/ GCS<5/ dilated and non-reacting pupil/had taken rTPA, 12 hours before the time of surgery plan. Our study result was also compared to other similar studies. We found the mortality is 25.58% in the surgery group, as compared to 48.53% of the patients treated medically. We concluded that craniotomy done within 48hours of admission definitely improves the mortality rate.

Keywords: Stroke, Malignant MCA infarction, Decompressive craniotomy

Introduction:

Stroke is the third most common cause of death worldwide, after coronary heart disease and Cancer (1). Asians as well as Indians have a higher rate of stroke than coronary heart disease, and in India, the mortality rate of stroke is 1.2% irrespective of age (2). Stroke due to occlusion of the proximal middle cerebral artery (MCA) involves a large portion of the ipsilateral hemisphere and may cause brain edema, leading to rapid neurological deterioration and death (3). Hacke et al first coined the term 'malignant' for a complete MCA territory infarction, causing brain edema and which leads to a rapid neurological deterioration (4). Approximately 1-10% of all MCA territory infarctions may turn into malignant MCA

infarction with a mortality rate of up to 80% within the first week (3).

Malignant MCA stroke is indicated by occlusion of more than 50% or, often, complete MCA blockage as evidenced in a CT scan of the brain. There is a perfusion deficit in more than 66% in the CT scan, and infarct volume is more than 82ml within 6 hours of onset in the MRI scan, and infarct volume is more than 145ml within 14 hours of onset in the MRI brain. In malignant MCA territory infarction, initially cytotoxic edema develops, followed by vasogenic edema within 48 hours of onset that leads to elevated Intracranial Pressure, followed by tentorial herniation with compression of the

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posterior cerebral artery and poor perfusion of the contralateral cerebral hemisphere, which leads to rapid deterioration of consciousness and death usually within the first week (3,5). Intensive care with mechanical ventilation, osmotic diuretics, hypothermia, sedation, and hyperventilation is often effective, with reported mortality rates being as high as 80% despite optimum medical treatment (5,6). One of the earliest reports on decompressive craniectomy for malignant MCA infarction was published in 1951 (7). Unilateral decompressive hemicraniectomy allows edematous brain tissue to herniate outside, thus preventing neuronal damage in the other part of the brain (8).

Materials and Methods

This is a retrospective study of patients diagnosed with malignant MCA territory infarction admitted to our hospital between January 2014 and December 2023. 246 patients between the ages of 37 and 94

years were included in this study. Patients with infarction of at least two-thirds of MCA territory with evidence of space-occupying edema and mass effect on the first computed tomographic (CT) scan of the brain were included in this study. ABC/2 method, though having high intra and inter-rater variability (71-99%), was used to estimate the volume of infarct, as it is a rapid and more or less accurate method (9). An MRI brain was performed in all cases within the first 12 hours of admission, and it helped to determine the infarct volume and mass effect more vividly. Surgery, in the form of decompressive craniectomy with lax duraplasty, in selected cases, was done under general anesthesia and Orotracheal intubation within 48 hours of admission. The extended Glasgow outcome score and mortality at the end of 8 weeks were noted in both (surgically and medically treated) groups, and the modified Rankin score was noted at 12 weeks.

Table 1: Extended Glasgow Outcome Score (10):

1	Death
2	Persistent vegetative State
3	Lower severe Disability: Requires full assistance
4	Upper Severe Disability: Requires some assistance
5	Lower Moderate Disability: Independent but unable to resume work
6	Upper Moderate Disability: able to resume some work
7	Lower Good Recovery: near normal with some problems
8	Upper Good Recovery

Table 2: Modified Rankin Scale (11):

0	No Symptom
1	No significant Disability
2	Slight Disability, Able to look after own activities without assistance
3	Moderate Disability. Requires some help
4	Moderate Severe Disability. Needs assistance in every aspect
5	Severe Disability. Bedridden and incontinent
6	Death

Aims and Objectives:

The primary Aim of this short study is to determine the result of surgical intervention done within 48 hours of admission in malignant MCA territory infarction with respect to mortality and outcome, and also to compare our results with other similar studies.

Results and Discussion

The total number of patients admitted to our hospital with a diagnosis of middle meningeal artery stroke was 5478. Among them, 246 patients were diagnosed as having malignant MCA territory infarction during the study period. The mean age of patients diagnosed with malignant middle meningeal artery infarction was 74.5 years with a range of 37 to 94 years. There was a male preponderance comprising 148 male and 98 female patients. The right hemisphere was affected in 176 patients. Glasgow Coma Score at admission was in the range of 3 to 8, and the mean was 5. A CT scan was done in every patient within the first 24 hours, and the mean time of initial imaging was 6.5 hours after the onset of stroke. Infarct volume was in the range of 90 ml to 160 ml, and the mean volume was 110 ml in MRI, done within the first 24 hr. Mean midline shift in the initial CT scan was 9.6 mm with a range

of 8mm to 12mm. 92 Patients were excluded from this study because of their age >65 years/ GCS <5 / dilated and non-reacting pupil/having received rTPA. (Alteplase) within 12 hours before the time of surgery. Relatives of 86 patients gave consent for surgery with informed high-risk consent, and the rest (68) denied it. Decompressive craniectomy measuring 10 × 12 cm in diameter with lax duraplasty by Temporalis fascia was done within the first 48 hours of admission in patients whose relatives agreed to it.

Medical therapy with osmotic diuretics and mechanical ventilation, as needed, was continued in others. All patients who underwent craniectomy were shifted to the intensive care unit for 24-48 h, and weaning of therapy was considered based on clinical, biochemical, and radiological findings. Exact intracranial pressure monitoring was not possible due to a lack of infrastructural facilities, and we had to depend solely on clinical parameters. A follow-up CT scan was done during the immediate post-surgery period in all postoperative patients.

Extended Glasgow outcome score (GOSE) at 8 weeks, mortality at 8 weeks, and Modified Rankin Scale (MRS) at 12 weeks were noted and tabulated as below:

Table 3: GOSE at 8 weeks: n=154

GOSE	8	7	6	5	4	3	2	1
Surgery N=86	0	0	2	12	34	9	8	21
Medical N=68	0	0	3	4	18	4	6	33

Table 4: Modified Rankin scale at 12 weeks:

mRS	0	1	2	3	4	5	6
Surgery N=86	0	0	0	34	22	8	22
Medical n-68	0	0	0	13	16	6	33

Table 5: dichotomized outcomes:

Group	Favorable GOSE 4-6	Unfavorable GOSE 1-3
Surgery n=86	48(55.8%)	38(44.2%)
Medical n=68	25(36.8%)	43(63.2%)

Statistical Analysis

We used R software and Python for statistical analysis of our results. The distribution of GOSE scores at 8 weeks was compared between the surgery group (n=86) and the medical group (n=68). A Chi-square test of independence was performed to assess differences in outcome distribution between the two groups. Chi-square value (χ^2) = 12.06, Degrees of freedom (df) = 5, p-value = 0.034. Since $p < 0.05$, there is a statistically significant difference in the distribution of GOSE outcomes between surgery and medical groups at 8 weeks.

Notably, a higher proportion of patients in the medical group remained at GOSE 1 (48.5%), compared to the surgery group (24.4%), indicating poorer short-term outcomes in the medically treated cohort. Conversely, the surgery group showed a relatively higher proportion of patients achieving intermediate recovery states (GOSE 4–5). For analysis, outcomes were dichotomized as in Table 5.

A Chi-square test comparing favorable vs unfavorable outcomes between the two groups showed Chi-square value (χ^2) = 4.79, Degrees of freedom (df) = 1, and p-value = 0.029. This indicates a statistically significant difference in short-term outcomes between the groups. Surgery group: 55.8% achieved favorable outcomes, whereas, medical group: 36.8% achieved favorable outcomes. As a

conclusion, at 8 weeks, the distribution of GOSE outcomes differed significantly between the surgical and medical cohorts. In the surgery group (n=86), 55.8% of patients achieved favorable outcomes (GOSE 4–6) compared with 36.8% in the medical group (n=68). Conversely, unfavorable outcomes (GOSE 1–3) were more frequent in the medical group (63.2%) than in the surgical group (44.2%). The difference was statistically significant (χ^2 = 4.79, df = 1, $p = 0.029$). Patients treated surgically had more than twice the odds of attaining a favorable outcome compared to those managed medically (OR = 2.17, 95% CI: 1.13–4.17). These findings indicate that surgical management was associated with significantly improved short-term functional recovery at 8 weeks compared with medical therapy alone.

While analyzing the result of mRS at 12 weeks, we found that both groups had no patients in mRS 0–2 (no good recovery). Most patients are clustered in mRS 3–6. The Surgery group has more patients in mRS 3–4 (moderate–severe disability), while the medical group has more in mRS 6 (death).

Simplified Dichotomization (Good vs. Poor Outcome): Since all patients fall in mRS 3–6, we could group: Survivors = mRS 3–5, Deaths = mRS 6

Table 6: Survivors (mRS 3-5) and Death(mRS-6):

Outcome	Surgery n=86	Medical n=68
Survivors (mRS 3-5)	64(74.4%)	35(51.5%)
Death(mRS-6)	22(25.6%)	33(48.5%)

In our cohort, survival was significantly higher in the surgical group compared to the medical group (74.4% vs. 51.5%). On dichotomized analysis (survivors mRS 3–5 vs. deaths mRS 6), the difference was statistically significant (Chi-square $p = 0.0054$; Fisher's exact $p = 0.0040$). Surgery was associated with 2.74-fold higher odds of survival compared to medical management (OR = 2.74, 95% CI: 1.39–5.41). These findings suggest that surgical intervention may confer a survival advantage over medical management in patients with malignant middle cerebral artery infarction. While both groups demonstrated poor functional recovery (no patients achieved mRS 0–2), the surgical group had substantially lower mortality rates (25.6% vs. 48.5%).

3 important trials have studied the effect of decompressive hemicraniectomy for malignant MCA strokes in patients <60 years of age.

DESTINY trial (2007), a prospective multicentric randomized controlled study from Germany, with projected sample size $n=188$, showed 88% vs 47% survival in favor of surgery (12). DECIMAL trial (2007) is another study from France ($n=38$) that showed a similar result of 75% vs 22% survival in favor of surgery (13). HAMLET trial (2009), from the Netherlands ($n=64$), also reported a favorable result in the decompressive craniectomy group (14). Vahedi et al in 2007 reported reduced death rate (22% in comparison to 71%) in surgically treated patients (15).

DESTINY II Trial (2014) studied patients aged >60 years ($n=112$, median age 70years), showed an outcome of survival without severe disability in 38% of the hemicraniectomy group in comparison to 18% in control (16).

In our study, the incidence of malignant middle cerebral artery infarction among all cases of MCA infarct is 4.49%, which is comparable to other studies, which claim it to be less than 10% of all supratentorial infarcts (17). Multiple studies

confirmed the significant improvement in mortality in malignant MCA territory infarct after decompressive craniotomy. It is estimated that a malignant MCA territory infarct has a mortality of nearly 80% as a natural history (5,6). In our study, the overall mortality is 50.81%. in the surgery group, there are 22(25.58%), 33(48.53%) in medically treated patients in the study group, and 70(76.08%) among the patients with malignant MCA infarct excluded from this study for their age (>65 years) and clinical status (GCS < 5 and/or dilated pupil. We have performed the craniotomy as a lifesaving procedure within 48 hours to get better results, though some study claims that the results of surgery even beyond 48 hours are not different (18). Some studies show better neurological outcome in ultra-early decompressive craniotomy (19). The European Stroke Organization (ESO) recommends decompressive craniotomy within 48 h after symptom onset in patients up to 60 years of age (20). A study by Schirmer et al suggests better outcomes if decompressive craniotomy is done within 24 hours (21). Surgery within 48 h of stroke likely improves outcome; the benefit of decompressive craniotomy after 48 hours is uncertain, although mortality may be reduced (19).

We found no significant difference between the dominant and non-dominant side infarct in both the surgery and no-surgery groups, as compared to other studies (22,23). The age of our study group was less than 65 years. Yao et al specifically compared results between younger patients < 60 years and elderly patients > 60 years after decompressive craniectomy and showed a mortality rate of 7.7% vs 33.3% (24). Mortality, in our study, was higher in obese patients, patients with midline shift more than 10mm on initial CT scan, patients with poorly controlled diabetes, untreated dyslipidemia, and in females. Complications like hemorrhagic complications, infections, and CSF compartment-related complications may occur early or even several months after decompressive craniotomy in

malignant MCA infarction (25). Hemorrhagic transformation of the infarct was found in 22(18.92%) in craniotomy and 19(27.94%) in medically treated patients. Subdural hygroma developed in 12(13.95%) of post-craniotomy patients. A two-post craniotomy patient developed an intraventricular hemorrhage that needed an External Ventricular drainage catheter placement. Apart from these, we faced some other common complications related to chest infection, tracheostomy-related complications, dyselectrolytemia, urinary tract infections, etc.

Conclusion:

Decompressive craniotomy improves survival in malignant middle cerebral artery infarction, but may increase the proportion of patients with significant disability. The mRS measures outcome mostly based on motor performance. It is a debatable issue that the measurement of quality of life must be considered with the patient's quality of motor improvement. Long-term follow-up and dedicated rehabilitation therapy are necessary to achieve an optimum outcome.

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