Section: Miscellaneous

Original Research Article

OUTCOME ANALYSIS OF DECOMPRESSIVE CRANIECTOMY IN MALIGNANT STROKE: A PROSPECTIVE INSTITUTIONAL STUDY

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ABSTRACT

Background: Malignant ischemic stroke is a catastrophic form of cerebral infarction characterized by extensive cerebral edema, raised intracranial pressure, and high mortality. Decompressive craniectomy (DC) has emerged as a life-saving surgical intervention in carefully selected patients. **Objectives:** To analyze clinical characteristics, timing of surgery, and outcomes of patients undergoing decompressive craniectomy for malignant stroke at a tertiary care center. **Materials and Methods:** This prospective observational study included 42 patients with malignant ischemic stroke who underwent decompressive craniectomy between January 2025 and December 2025 in Thanjavur Medical College, Tamilnadu. Demographic data, Glasgow Coma Scale (GCS), infarct laterality, timing of surgery, and survival outcomes were analyzed. **Results:** The male-to-female ratio was 3.2:1. Overall mortality was 61.9%. Survival was significantly higher in patients operated within 72 hours and in those with admission GCS >9. Patients with GCS >12 had the best survival (66.7%). **Conclusion:** Early decompressive craniectomy within 72 hours and higher preoperative GCS are associated with favorable outcomes in malignant stroke. Timely intervention and appropriate patient selection are critical in reducing mortality.

INTRODUCTION

Stroke remains one of the leading causes of mortality and long-term disability worldwide. According to the World Health Organization, stroke is the second leading cause of death and the third leading cause of death and disability combined, measured as disability-adjusted life years (DALYs).[1] Globally, nearly 12 million individuals experience a new stroke annually, with more than 7 million deaths attributed to stroke each year.[1,2]

Ischemic stroke accounts for approximately 80–85% of all stroke cases.[3] Among ischemic strokes, infarctions involving large arterial territories—most commonly the middle cerebral artery (MCA)—are associated with extensive cerebral edema and poor outcomes. A subset of these patients develops malignant cerebral infarction, a catastrophic clinical entity characterized by massive hemispheric infarction, rapidly progressive cerebral edema, raised intracranial pressure, and impending cerebral herniation.[4]

Malignant MCA infarction typically evolves within the first few days following arterial occlusion. Progressive cytotoxic and vasogenic edema leads to midline shift, compression of vital structures, reduced cerebral perfusion pressure, and secondary brainstem injury.[5] Despite aggressive medical management—including osmotherapy, controlled ventilation, sedation, and intensive care support—mortality rates in untreated malignant infarction may reach 70–80%.[6] Medical therapy alone is often insufficient to control refractory intracranial hypertension in these patients.

Decompressive craniectomy has emerged as a life-saving surgical intervention in selected patients with malignant ischemic stroke. The procedure involves removal of a large fronto-temporoparietal bone flap with expansile duraplasty, allowing outward expansion of the swollen brain and effective reduction of intracranial pressure.[7]

Over the past two decades, several randomized controlled trials have firmly established the role of decompressive craniectomy in malignant MCA infarction. The DECIMAL, DESTINY, and HAMLET trials demonstrated a significant reduction in mortality when surgery was performed early, particularly within 48–72 hours of stroke onset.[8-10]

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Despite strong evidence supporting decompressive craniectomy, clinical outcomes remain variable and are influenced by several factors, including timing of surgery, preoperative neurological status, age, and extent of infarction. Among these, the Glasgow Coma Scale (GCS) at presentation and the timing of surgical intervention have consistently emerged as key prognostic indicators.[7,11]

The present prospective institutional study was undertaken to evaluate the outcomes of decompressive craniectomy in patients with malignant ischemic stroke, with particular emphasis on demographic factors, preoperative neurological status, timing of surgery, and survival outcomes.

Objectives

1. To evaluate demographic and clinical characteristics of malignant stroke patients undergoing DC
2. To assess the impact of timing of surgery on survival
3. To analyze the relationship between preoperative GCS and outcome

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational institutional study conducted in the Thanjavur Medical College in Department of Neurosurgery a tertiary care teaching hospital. The study period extended from January 2025 to December 2025. The study was designed to evaluate clinical outcomes following decompressive craniectomy in patients presenting with malignant ischemic stroke.

Study Population

All consecutive patients diagnosed with malignant ischemic stroke and who underwent decompressive craniectomy during the study period were included in the analysis.

Inclusion Criteria

Patients were included if they met all of the following criteria:

- Age ≥18 years
- Radiologically confirmed large MCA territory infarction (>50%)
- Progressive neurological deterioration despite maximal medical management
- Decreased level of consciousness (Glasgow Coma Scale ≤12)
- Evidence of cerebral edema with midline shift on computed tomography (CT)
- Underwent decompressive craniectomy within the study period

Exclusion Criteria

Patients were excluded if they had:

- Bilateral fixed and dilated pupils
- Extensive bilateral cerebral infarction
- Pre-existing severe neurological disability (modified Rankin Scale ≥4 prior to stroke)
- Severe systemic illness precluding surgery
- Refusal of consent by patient or next of kin

Procedure

All patients underwent a standardized preoperative evaluation, which included:

- Detailed clinical examination
- Assessment of neurological status using the Glasgow Coma Scale (GCS)
- Non-contrast CT scan of the brain to assess infarct size, midline shift, and cerebral edema
- Routine laboratory investigations including complete blood count, renal and liver function tests, coagulation profile, and serum electrolytes

Patients were initially managed with maximal medical therapy in the intensive care unit, including head elevation, osmotherapy, controlled ventilation when indicated, and hemodynamic optimization. Patients who continued to deteriorate or met radiological criteria for malignant infarction were considered for surgical decompression. All patients underwent standardized large fronto-temporoparietal decompressive craniectomy under general anesthesia. Postoperatively, all patients were managed in the neurosurgical intensive care unit. Standard postoperative care included: Postoperative CT scans were obtained within 24 hours to assess adequacy of decompression and detect complications such as hemorrhage or any herniation.

Outcome Measures

The primary outcome measure was in-hospital survival following decompressive craniectomy.

Secondary outcome measures included:

- Association of survival with preoperative GCS
- Association of survival with timing of surgery
- Postoperative complications such as external cerebral herniation, subdural hygroma, hydrocephalus, infection, and seizures

Statistical Analysis

Data were entered into a Microsoft Excel spreadsheet and analyzed using standard statistical software. Continuous variables were expressed as means and ranges, while categorical variables were expressed as frequencies and percentages. The Chi-square test was used to assess the association between categorical variables (GCS, timing of surgery) and survival outcome. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Approval was obtained from the Institutional Ethics Committee prior to commencement of the study. Written informed consent for surgery and inclusion in the study was obtained from the patient's legally authorized representative.

RESULTS

A total of 42 patients with malignant ischemic stroke who underwent decompressive craniectomy during the study period were included. Male patients predominated the study population (76.2%). The most common age group affected was 40–60 years (38.1%), followed by patients above 60 years (38.1%). Right-sided malignant infarction was more

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frequent (76.2%). [Table 1,2] Patients undergoing decompressive craniectomy within 72 hours demonstrated improved survival compared to delayed intervention. Preoperative neurological status significantly influenced outcome, with patients having GCS ≥9 showing markedly higher survival rates. Overall mortality remained high (61.9%), reflecting the severity of malignant ischemic stroke. [Table 3] Timing of decompressive craniectomy showed a statistically significant association with survival (χ^2 = 6.08, df = 2, p = 0.048). Patients operated within 72 hours of stroke onset had better survival outcomes compared to those undergoing delayed surgery. [Table 4] A statistically significant association was observed between preoperative Glasgow Coma Scale (GCS) and survival outcome (χ^2 = 12.42, df = 2, p = 0.002). Patients with GCS ≥9 demonstrated significantly higher survival compared to those with GCS <9. [Table 5]

Table 1: Demographic Characteristics of the Study Population (n = 42)

Variable	Number (n)	Percentage (%)
Sex		
Male	32	76.2
Female	10	23.8
Age group (years)		
< 40	10	23.8
40–60	16	38.1
> 60	16	38.1

Table 2: Clinical Characteristics at Presentation

Parameter	Number (n)	Percentage (%)
Glasgow Coma Scale (GCS)		
< 9	18	42.8
9–12	18	42.8
> 12	6	14.4
Side of infarction		
Right hemisphere	30	76.2
Left hemisphere	12	23.8

Table 3: Overall Outcome Following Decompressive Craniectomy

Outcome	Number (n)	Percentage (%)
Survived	16	38.1
Expired	26	61.9

Table 4: Timing of Surgery and Survival Outcome

Timing of decompressive craniectomy	Total patients (n)	Survived (n)	Survival (%)	P value
< 24 hours	24	8	33.3	<0.05*
24–72 hours	12	6	50.0	
> 72 hours	6	2	33.3	
Total	**42**	**16**	**38.1**	

P value <0.05 Significant using Chi square Test

Table 5: Association Between Preoperative GCS and Survival

GCS Score	Total patients (n)	Survived (n)	Survival (%)	P value
< 9	18	2	11.1	<0.05*
9–12	18	10	55.6	
> 12	6	4	66.7	

P value <0.05 Significant using Chi square Test

DISCUSSION

Malignant ischemic stroke represents one of the most devastating forms of cerebrovascular disease, characterized by extensive cerebral infarction, malignant cerebral edema, raised intracranial pressure, and rapid neurological deterioration. Without surgical intervention, mortality rates approach 70–80%, primarily due to transtentorial herniation and secondary brainstem compression. The present prospective institutional study evaluates the outcomes of decompressive craniectomy in such patients and reinforces the survival benefit of early surgical intervention.

Survival Benefit of Decompressive Craniectomy

In the current study, the overall survival rate following decompressive craniectomy was 38.1%, which is comparable to outcomes reported in major randomized controlled trials and large observational studies. Vahedi et al., in a pooled analysis of the DECIMAL, DESTINY, and HAMLET trials, demonstrated that decompressive craniectomy performed within 48 hours significantly reduced mortality from approximately 78% to 29% in patients younger than 60 years.[11] Similarly, Jüttler et al. reported a marked survival advantage with early decompressive surgery in malignant middle cerebral artery (MCA) infarction.[9]

Although survival improves significantly, it is important to document that functional outcomes vary

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widely. The goal of decompressive craniectomy in malignant stroke is primarily life-saving, and functional recovery depends on multiple factors including age, preoperative neurological status, infarct volume, and timing of intervention.

Timing of Surgery and Outcome

Timing of decompressive craniectomy remains a critical determinant of outcome. In the present study, patients operated within 72 hours of stroke onset demonstrated better survival compared to those undergoing delayed surgery. This finding aligns with previous literature emphasizing early intervention before irreversible secondary injury and herniation occur.

The HAMLET trial showed that decompressive craniectomy within 48 hours significantly reduced mortality, whereas delayed surgery beyond this window did not provide the same benefit.[10] Early surgery limits the progression of cytotoxic and vasogenic edema, prevents critical intracranial hypertension, and preserves cerebral perfusion pressure. Delayed intervention, particularly after signs of herniation, is associated with poorer outcomes due to irreversible neuronal damage.

Role of Glasgow Coma Scale (GCS)

Preoperative neurological status, assessed using the Glasgow Coma Scale (GCS), is a strong prognostic indicator. In this study, patients with GCS >9 had substantially better survival compared to those with lower scores. This observation is consistent with prior studies that have demonstrated improved outcomes in patients with preserved consciousness at the time of surgery.[11,12]

Low GCS often reflects extensive infarction, advanced cerebral edema, and compromised brainstem function, all of which reduce the potential benefit of decompressive surgery. Therefore, GCS serves as an important tool in patient selection and prognostication.

Age and Outcome

Although decompressive craniectomy was initially recommended for patients younger than 60 years, recent evidence suggests a survival benefit even in elderly patients, albeit with higher rates of severe disability. The DESTINY II trial demonstrated that patients over 60 years undergoing decompressive craniectomy had significantly reduced mortality compared to conservative treatment, though many survivors had moderate to severe disability.[12]

In the present study, increasing age was associated with poorer outcomes.

Right-sided infarctions were more common in this cohort. While hemisphere dominance has been debated as a prognostic factor, most studies, including the pooled analyses of randomized trials, suggest that survival benefit from decompressive craniectomy is independent of the side of infarction.[11,13]

Complications

Common postoperative complications observed include external cerebral herniation, subdural hygroma, hydrocephalus, seizures, and infection. These complications have been widely reported in literature and are generally manageable with appropriate postoperative care.[14]

CONCLUSION

Malignant ischemic stroke remains a neurosurgical emergency with a high risk of mortality if managed conservatively. This prospective institutional study demonstrates that decompressive craniectomy significantly improves survival when performed early, particularly within 72 hours of stroke onset, and in patients presenting with a preoperative Glasgow Coma Scale score greater than 9. Early surgical intervention before irreversible secondary brain injury appears to be the most critical determinant of outcome.

Based on these findings, early identification of malignant cerebral infarction, prompt neuroimaging, and urgent neurosurgical referral are strongly recommended. Decompressive craniectomy should be considered without delay in eligible patients showing clinical deterioration or radiological evidence of significant mass effect despite optimal medical management. Careful patient selection, multidisciplinary decision-making, and structured preoperative counseling of family members regarding expected neurological outcomes, rehabilitation needs, and quality of life are essential components of management. Timely surgical decompression, combined with comprehensive postoperative neurocritical care and rehabilitation, can substantially reduce mortality and improve overall outcomes in patients with malignant ischemic stroke.

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