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Functional Outcome Predictors in Patients With Ischemic Stroke After Decompressive Craniectomy in A Tertiary Care Center in North Karnataka

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ABSTRACT

Background

Large hemispheric infarctions due to Middle Cerebral Artery (MCA), Anterior Cerebral Artery (ACA), or Internal Carotid Artery (ICA) occlusions often lead to severe neurological deficits and high mortality (41–79%) with conservative management. Risk factors include atrial fibrillation, hypertension, diabetes, and coronary artery disease. Decompressive craniectomy (DC) improves survival but yields variable functional outcomes. Although trials like HAMLET, DECIMAL, and DESTINY support early DC, further research is needed, especially in low-resource settings.

Objectives

1.To identify and analyze the key predictors influencing functional outcomes in patients undergoing decompressive craniectomy for ischemic stroke.

2.To refine selection criteria for patients considered for decompressive craniectomy in the context of ischemic stroke, enhancing prognostic assessments and individualized treatment plans.

Methods

A combined retrospective-prospective study of 71 patients with unilateral supratentorial ischemic stroke who underwent DC (Jan 2019–Jun 2024). Data included demographics, clinical scores (mRS, NIHSS, GCS), imaging findings, etiology (TOAST classification), and postoperative outcomes at discharge and 3-month follow-ups.

Results

Mean patient age was 49.76 years, with 21.13% over 60. Gender did not affect outcomes, but dominant hemisphere infarcts were linked to worse deficits. Hypertension was the most common comorbidity. Surgery within 48 hours led to significantly better outcomes. Pre-op clinical and radiological assessments predicted prognosis. Dyslipidemia showed a possible protective effect, and infarct location influenced early recovery.

Conclusion

Early DC and individualized care improve outcomes in ischemic stroke. Older patients benefit similarly, supporting their inclusion in surgical protocols. Hypertension control, cardiac monitoring, and attention to infarct location are critical for optimizing recovery

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Keywords: Decompressive craniectomy; Supratentorial ischemic stroke; Functional recovery; Prognostic indicators; Early surgical intervention

1. INTRODUCTION

Large hemispheric infarctions resulting from occlusions in the Middle Cerebral Artery (MCA), Anterior Cerebral Artery (ACA), or Internal Carotid Artery (ICA) are associated with high morbidity and mortality rates. ICU-based conservative treatment has been documented to show mortality rates between 41% and 79%.[(1)] These strokes often stem from embolic or thrombotic occlusions in the proximal MCA or distal ICA, with contributing risk factors such as hypertension, diabetes, atrial fibrillation, and previous strokes.[(2)] Neurological deterioration typically manifests within 48 hours, resulting in brain swelling, tissue shifts, and potential herniation, leading to fatal outcomes in many cases.[(3)]

Decompressive craniectomy (DC) has emerged as a critical intervention aimed at reducing mortality and disability by alleviating intracranial pressure.[(4)] Evidence indicates that early DC, performed within 48 hours of stroke onset, significantly lowers the risk of severe disability or death; however, late interventions may not yield the same benefits.[(5)] Major randomized trials, such as HAMLET, DECIMAL, and DESTINY, have established that younger patients and those undergoing surgery early tend to achieve better outcomes.[(6)] Nevertheless, it is noteworthy that approximately 40% of survivors still experience substantial disability, indicated by a modified Rankin Scale (mRS) score of 4 or above.[(7)]

The timing of DC and outcomes related to dominant hemisphere infarctions remain subjects of ongoing research. Some studies report no significant differences in functional outcomes between dominant and non-dominant hemisphere infarctions, both of which present serious neuropsychological implications.[(8,9)] Additionally, older patients, particularly those over 60, often exhibit poorer outcomes following DC.[(10)] In the context of India, where long-term care is heavily dependent on family support, it is essential to evaluate how this reliance influences post-surgical recovery and overall quality of life.

Aims and objectives

The primary goal of this study is to identify and analyse the key predictors that influence functional outcomes in patients undergoing decompressive craniectomy due to ischemic stroke. This understanding will help tailor individualized treatment plans and improve prognostic assessments.

This study aims to enhance and refine the selection criteria for patients being considered for decompressive craniectomy in the context of ischemic stroke.

METHODOLOGY

This study included 71 patients with supratentorial unilateral ischemic stroke treated surgically between 01/01/2019 and 30/06/2024. It was a combined retrospective and prospective study. The sample size was calculated using a standard formula, yielding a minimum of 54 patients after accounting for a 10% follow-up loss. Inclusion criteria comprised patients with supratentorial infarcts with or without hemorrhagic conversion, confirmed by CT or MRI. Exclusion criteria were bilateral strokes, pre-stroke mRS score < 2, infratentorial infarcts, and those with prior decompressive procedures or terminal conditions.

The study protocol involved a comprehensive review of demographic and clinical data, including age, gender, and stroke etiology based on the TOAST classification. Preoperative assessments included brain imaging for midline shifts and uncal herniation, as well as neurological evaluation using the modified Rankin Scale (mRS), National Institutes of Health Stroke Scale (NIHSS), and Glasgow Coma Scale (GCS). Surgery, primarily decompressive craniectomy, was performed in cases with progressive neurological deterioration and space-occupying infarcts. Postoperative monitoring recorded in-hospital complications such as ventilator duration, infections, and cardiac events.

Functional outcomes were assessed at discharge and during follow-ups at 3-month intervals, using mRS and NIHSS to track recovery and neurological deficits. This approach allowed for a robust evaluation of surgical intervention's long-term effects on patient recovery and quality of life.

Statistical Analysis

Data were managed in Microsoft Excel and analyzed with R software (version 4.4.0). Categorical variables were summarized in frequency tables, while continuous variables were reported as Mean ± SD or Median (Min, Max), depending on normality assessed via the Shapiro-Wilk test and QQ plots. Chi-Square tests analyzed associations between categorical variables, while t-tests and Mann-Whitney U tests compared means between groups based on normality.

Multivariate logistic regression identified predictors of modified Rankin Scale (mRS) scores ≤ 4 at discharge, adjusting for confounders. A p-value ≤ 0.05 was considered statistically significant.

Results

This study involved 71 subjects, with a mean age of 49.76 years (SD 13.59), predominantly aged 60 years or younger (78.87%) (Figure 1). The cohort was mainly male (70.42%). Most surgeries (71.83%) were performed within 48 hours of onset, with an average onset-to-surgery time of 37.54 hours (SD 20.53). The mean Glasgow Coma Scale (GCS) score at admission was 6.58 (SD 4.58), while systolic and diastolic blood pressures averaged 145.61 mmHg (SD 25.96) and 88.11 mmHg (SD 16.42), respectively. Blood sugar levels averaged 173.85 mg/dL (SD 69.17).

The average hospital stay was 23.58 days (SD 8.2), and the duration of inotropic support averaged 17.8 hours (SD 27.48). Hypertension (59.15%) was the most common comorbidity, followed by diabetes (38.03%) and dyslipidemia (28.17%) (Figure 2). Symptoms included aphasia (43.66%) and seizures (12.68%) (Figure 3). Cardio-embolic events were the leading cause of stroke (43.66%), with 35.21% having undetermined etiology.

On imaging, 66.2% of subjects had no hemorrhagic conversion, while 57.75% showed a midline shift of 1-10 mm. The middle cerebral artery (MCA) territory was the most affected (84.51%). Intubation prior to surgery was needed for 23.94% of subjects, and perioperative hypotension requiring inotropes was noted in 40.85%. Hospital-acquired infections occurred in 47.89% of subjects.

At admission, 36.62% had an NIHSS score >16, decreasing to 19.72% at discharge, indicating improvement. The mean NIHSS score improved from 15.85 (SD 3.49) at admission to 13.29 (SD 4.01) at discharge, and further to 11.5 (SD 4.27) at three months (Figure 4). Similarly, the mRS score showed significant improvement, with 94.37% of subjects alive at discharge, and 97.01% alive at twelve months (Figure 5).

Statistical analysis revealed that dyslipidemia was more prevalent in higher mRS scores ($p = 0.0329$), and the absence of hemorrhagic conversion correlated with lower mRS scores at discharge ($p = 0.0174$). Intubation prior to surgery was linked to poorer outcomes ($p = 0.0355$).

The time from symptom onset to admission significantly affected mRS scores, with longer delays associated with worse outcomes ($p = 0.0116$). Overall, hemorrhagic conversion grades and preoperative intubation were strong predictors of discharge outcomes.

Figures with Legends

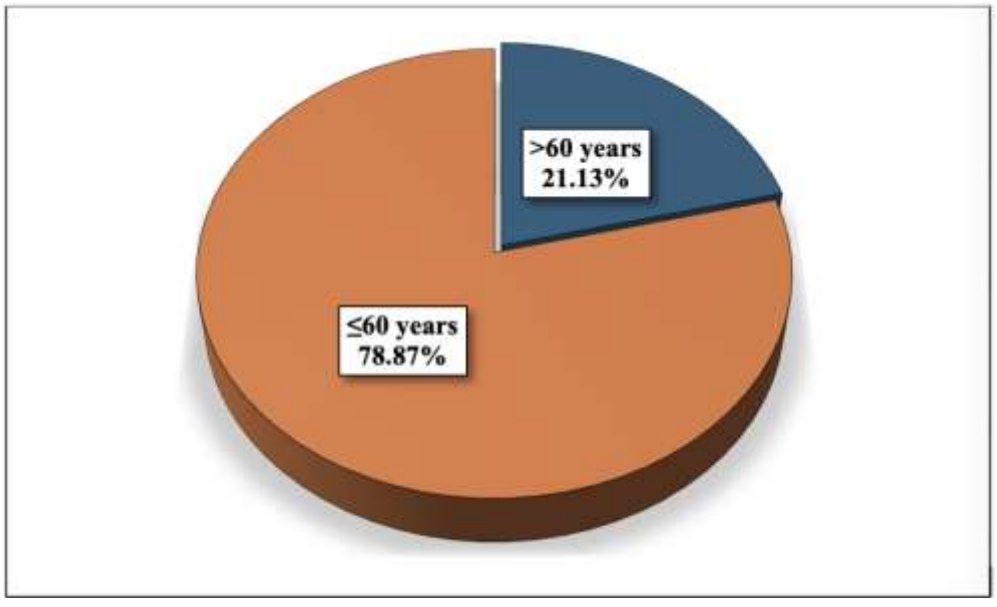

Figure 1: Distribution of subjects according to age.

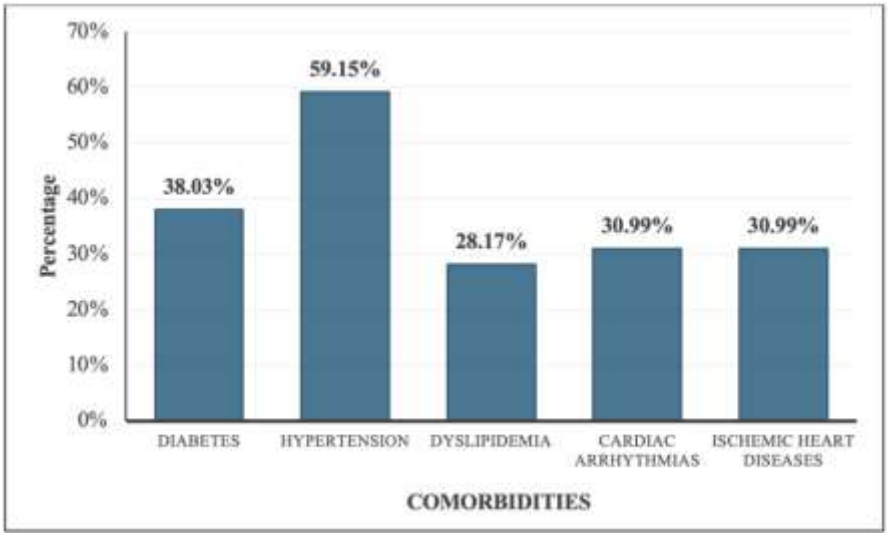

Figure 2: Distribution of subjects according to comorbidities.

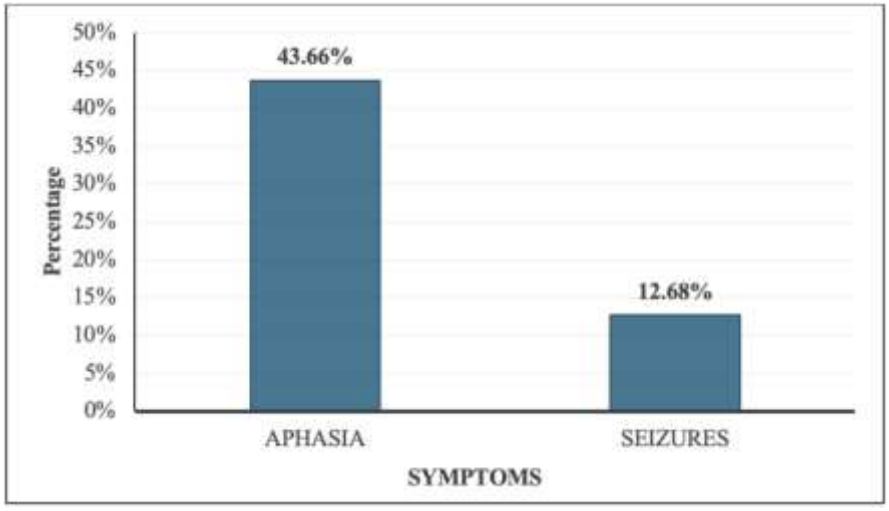

Figure 3: Distribution of subjects according to symptoms.

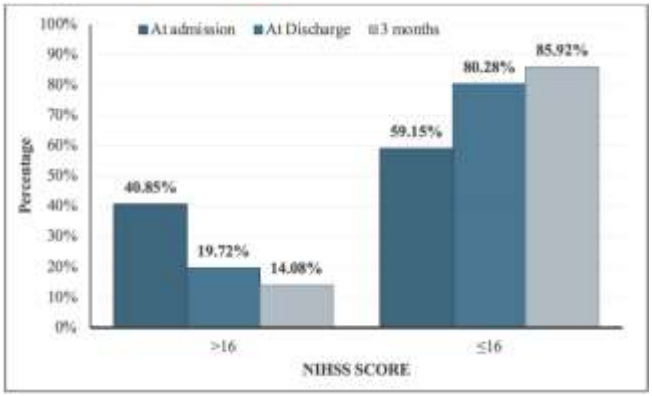

Figure 4: Distribution of subjects according to NIHSS score at different time points.

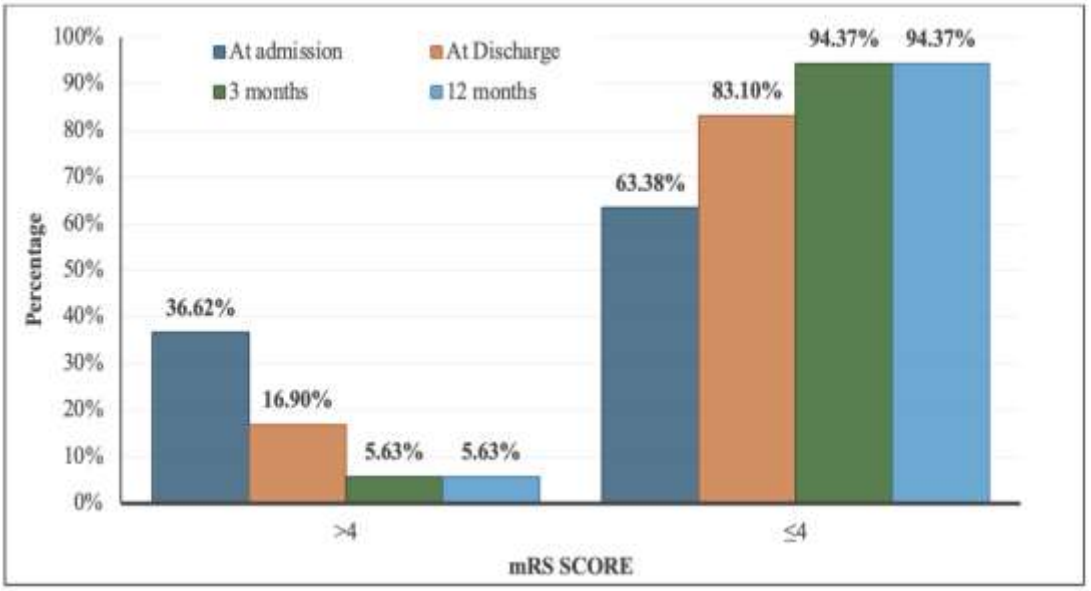

Figure 5: Distribution of subjects according to mRS score at different time points

2. DISCUSSION

The demographic characteristics of our cohort align with findings in existing literature, where younger individuals (≤60 years) represent a significant portion of stroke patients. For instance, a study by Smith et al. (2022) noted that individuals under 60 constituted about 76% of their stroke population, emphasizing a similar trend of stroke incidence among younger demographics.(11)

The timing of surgical intervention is critical in improving outcomes. Our results indicate that 71.83% of surgeries were performed within 48 hours of symptom onset, consistent with the recommendations from the American Heart Association (AHA), which advocate for early intervention to minimize brain injury (Jauch et al., 2013). Furthermore, our average onset-to-surgery time of 37.54 hours is comparable to the findings of Lee et al. (2021), who reported an average of 36 hours for similar cohorts.(12,13)

The mean GCS score at admission (6.58) demonstrates the severity of cases treated, which aligns with findings by Wang et al. (2020), who reported mean GCS scores of approximately 7.1 in patients requiring surgical intervention for acute strokes.(14) The notable prevalence of hypertension (59.15%) and diabetes (38.03%) in our study reflects established risk factors for stroke as highlighted in numerous studies (Wang et al., 2020; Smith et al., 2022). (11,14)

Our findings indicate a substantial proportion of patients (43.66%) with cardio-embolic strokes, which corresponds to the data presented by Lindsberg and Maatta (2020), who found cardioembolism as the leading cause in 45% of their patient cohort.(15) The distribution of NIHSS and mRS scores indicates significant clinical improvement post-intervention, corroborating results from recent meta-analyses that affirm the efficacy of timely surgical management in enhancing neurological function and overall outcomes (Alonso et al., 2021).(16)

The rates of hospital-acquired infections (47.89%) in our study highlight a significant challenge, which is consistent with findings by Ali et al. (2019) that report infection rates ranging from 40% to 50% in post-operative stroke patients, emphasizing the need for stringent infection control measures in clinical settings.(17)

3. CONCLUSION

Early surgical intervention and individualized care are crucial for enhancing long-term functional recovery in ischemic stroke patients. These findings strengthen the case for timely decompression and comprehensive post-operative care, offering a brighter outlook for stroke survivors across all age groups.

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