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Original Article

Outcome of Ischemic Stroke Patients Following Decompressive Craniectomy: A Cohort Study

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Abstract

Background: Decompressive craniectomy (DC) is effective in reducing mortality and improving outcomes in stroke patients. However, there is a need for a better understanding of the outcomes and complications of stroke, particularly in regions such as Iran, where comprehensive studies on DC outcomes are scarce. This study investigated the effects of DC in stroke patients.

Methods: This cohort study was conducted at Nemazi Hospital in Shiraz, Iran, from 2018 to 2020. All patients aged over 18 years with ischemic stroke requiring DC were included using census sampling. Data on demographics, clinical history, and imaging findings were collected. Outcomes were assessed using the modified rankin scale (mRS), Glasgow outcome score extended (GOSE), and aphasia severity rating (ASR).

Results: A total of 144 cerebral infarction patients underwent DC; 22 (15.3%) were lost to follow-up, and 67 (55%) of the remaining patients died either during hospitalization or within at least 6 months of follow-up. Patients over 60 years old (OR=0.152), those with a history of stroke (OR=0.227), and those with COVID-19 infection (OR=0.164) were associated with a decreased likelihood of survival. However, an increase in the Glasgow Coma Scale (GCS) score on admission was associated with an increased probability of survival (OR=1.199). The ordered logistic regression analysis showed that an increase in GCS score was associated with a higher probability of achieving better outcomes across all models: GOSE (OR=1.177), mRS (OR=0.839, with lower scores indicating better outcomes), and ASR (OR=1.354). The analysis showed that patients over 60 had a lower probability of achieving better outcomes in the GOSE model (OR=0.185) and were likely to have worse outcomes in the mRS model (OR=5.182).

Conclusion: These findings underscored the critical role of comorbidities (such as COVID-19 and prior stroke) and GCS scores in predicting patient survival and functional outcomes following DC. In particular, the higher mortality rates and poorer functional outcomes observed in older patients highlighted the need for careful consideration in this age group.

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Keywords ● Ischemic stroke ● Decompressive craniectomy ● Patients ● Iran

What's Known

- The efficacy of decompressive craniectomy in reducing mortality among ischemic stroke patients is well-established. However, previous studies have predominantly focused on functional outcomes in supratentorial strokes, with limited exploration of speech outcomes and infratentorial strokes.

What's New

- This study addressed both functional and speech outcomes in patients with supratentorial and infratentorial strokes. It revealed that patients aged over 60 years with a history of stroke and concurrent COVID-19 infection had a reduced likelihood of survival, while higher Glasgow Coma Scale scores on admission were associated with improved survival rates.
- The findings highlighted the potential relationships between neurological and functional parameters, as well as speech outcomes, offering new insights into post-stroke recovery.

Introduction

Stroke is a leading cause of death and disability-adjusted life year (DALY), with a rising global incidence and associated complications, disability, and economic burden.[1-3]

Cerebral infarction in the internal carotid artery (ICA) or middle cerebral artery (MCA) can result in significant ischemic damage, leading to malignant MCA syndrome. This condition often causes death within a few days due to brain tissue edema and herniation.[4, 5]

Malignant MCA infarction carries a very high mortality rate due to the increased risk of cerebral edema and brain tissue herniation.[6] Impairment of consciousness can occur within hours of symptom onset, and despite intervention and severe care, the estimated mortality rate remains quite high.[7] Studies based on intensive medical care reported high mortality rates, with most survivors experiencing severe disability.[8, 9] Due to the limitations of conservative treatments, decompressive craniectomy (DC) has emerged as a therapeutic approach to reduce mortality and improve functional outcomes.[10-12] DC creates additional space for the brain tissue to expand outward, reducing intracranial pressure (ICP) and preventing downward herniation. Assessments using the modified rankin scale (mRS) indicated that DC reduced severe disabilities and dependence among patients who underwent surgery compared to those who received only non-invasive treatments.[13, 14]

Some studies suggested that DC reduced mortality and improved functional outcomes in patients with hemispheric infarction, particularly when performed early within the first days of symptom onset.[15, 16] However, the treatment effect of DC varies based on age. While DC might lead to better outcomes in younger patients, elderly patients might have a poorer prospect of functional survival.[13] Conversely, a recent meta-analysis found that DC improved mortality and severe disability outcomes in malignant edema after ischemic stroke, with no significant difference based on age (<60 years vs. ≥60 years).[17] Additionally, evidence suggested that DC could significantly reduce mortality and improve functional recovery even among elderly patients.[11, 16]

While most studies have focused on DC outcomes in patients with malignant MCA syndrome, limited studies have been conducted on patients with cerebellar infarction. For extensive cerebellar infarction, few clinical trials have been conducted. However, studies demonstrated that suboccipital DC reduced mortality and improved outcomes in patients with extensive cerebellar stroke and edema.[18]

Patient's age, timing of surgical intervention, involvement of the dominant cerebral hemisphere, underlying disorders, medications, and pre-and post-surgical consciousness levels are critical determinants in predicting therapeutic outcomes after DC.[11] Evaluating the effectiveness of therapeutic interventions relies on assessing the performance of stroke survivors. While the mRS is commonly used, incorporating additional perspectives, such as social and behavioral interactions and verbal skills, can provide a more comprehensive understanding of post-cerebral infarction conditions. Unfortunately, speech disorders have received limited attention in many studies.

To address gaps in previous studies regarding age groups, supratentorial and infratentorial infarctions, and both functional and verbal outcomes, this study investigated the functional and verbal outcomes of ischemic stroke patients following DC. Furthermore, given the concurrent COVID-19 pandemic during the study period, this study also investigated its effect on the patient's outcome. Thus, this study aimed to evaluate the functional and verbal outcomes of ischemic stroke patients following DC.

Patients and Methods

This cohort study was conducted at Nemazi Hospital in Shiraz, Iran, a level three referral center for cerebral infarction patients undergoing DC surgery, from 2018 to 2020. The study included all eligible patients using a census sampling method. Inclusion criteria comprised adult patients (age ≥18 years) with ischemic stroke (both supratentorial and infratentorial ischemic cerebrovascular accidents [CVA]) who underwent DC surgery. Patients who underwent DC for reasons other than ischemic stroke or had significant defects in their clinical records were excluded. Indications for DC included a midline shift of more than 5 mm in supratentorial strokes, hydrocephalus, and brainstem compression in cerebellar infarctions.

The study adhered to international guidelines for clinical research, as outlined in the World Medical Association's Declaration of Helsinki, and received approval from the Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.MED.REC.1401.196).

After obtaining ethical approval, the clinical files of 144 patients were reviewed based on the study population and inclusion/exclusion criteria. Data collection was conducted in three stages.

Stage 1: Clinical and Demographic Data Collection

In the initial stage, the clinical and demographic data were recorded. After a thorough review of the clinical files, the relevant information was entered into a standardized data collection form for each patient. This form included demographic details, such as sex and age, as well as information on underlying diseases (e.g., diabetes mellitus [types 1 and 2], a history of stroke, hypertension, ischemic heart diseases, atrial fibrillation, dyslipidemia, hypothyroidism, and hyperthyroidism), and smoking status.

Considering the onset of the COVID-19 pandemic in early 2019, the impact of COVID-19 infection at the time of a stroke on patient outcomes was also investigated. Patients with COVID-19 infection, as documented in their medical history, were identified.

Furthermore, the Glasgow Coma Scale (GCS) score[19] of patients before surgery was recorded to evaluate its effect on the outcomes. The GCS score was determined through neurological examinations. The time interval between symptoms onset and surgery was also examined. Patients were divided into two groups: those with a time interval of less than 48 hours and those with a time interval of more than 48 hours. The volume of blood loss during surgery (measured in mm) was also documented to explore its relationship with patient outcomes.

Stage 2: Imaging Data Collection

In the second stage, brain computed tomography (CT) scans performed before and after surgery were reviewed. Based on the CT images, the following characteristics were determined and recorded: the type of stroke, location of the infarction, involved arterial branch, and the amount of midline shift (MLS) measured in mm on the last CT scan before DC surgery. To assess the impact of the occluded arterial branch on patient outcomes, the patients were categorized into three groups based on the involved arterial branch: left (lt) MCA, right (rt) MCA, and posterior circulation.

Surgical Procedures

For malignant MCA infarction, DC involved making a large frontotemporoparietal question-mark skin incision on the side of brain edema, removal of a bone flap larger than 15×15 cm using craniotome, and dural opening followed by duraplasty using pericranial fascia. For cerebellar infarction, the procedure included a midline occipitocervical incision, removal of a suboccipital bone flap (5 to 8 cm in diameter), and duraplasty by precranial facia.

Stage 3: Outcome Assessment

In the final stage of the study, a single interview was conducted with patients (or their relatives) who were discharged from the hospital after surgery, taking into account their overall condition, which included either discharge or death during hospitalization. The follow-up period was at least 6 months. For the respondents participating in the telephone interview, the details and purpose of the study were explained, and the respondent's relationship to the patient (patient /relatives) was recorded. After obtaining implicit consent from the respondents, the patient's overall outcome (death or survival), functional outcome (assessed using the mRS and Glasgow Outcome Score Extended [GOSE] criteria), and verbal outcome (assessed using the Aphasia Severity Rating [ASR]) were recorded.

The mRS is a commonly used scale to assess the level of disability or dependence in daily activities among individuals with neurological disabilities resulting from conditions such as stroke. The scale ranged from 0 (no symptoms) to 5 (severe disability), with a score of 6 indicating death. Outcomes were categorized into two groups: favorable (scores 0-3) and unfavorable (scores 4-6).[20]

The GOSE is an index used to classify patients with brain injuries, including stroke and traumatic brain injury, into eight groups based on their level of recovery. A score of 1 represents death, while higher scores indicate reduced disability and improved performance, with a score of 8 representing the highest level of recovery after brain damage.[21] During the telephone interviews, the mRS and GOSE index[22] were used to assess the functional outcomes of the patients.

This study also investigated the verbal outcome of cerebral infarction patients who underwent DC surgery. ASR was utilized to assess the verbal outcome of the patients. The ASR is a single observational rating scale designed to measure the severity of aphasic language impairment.[23] Based on this scale, patients are classified into five categories according to the severity of their speech disorder. During the telephone interviews, questions were asked about the patients' verbal outcomes, and their scores were recorded using the ASR to reflect the level of verbal impairment.

The time interval for evaluating the outcomes of DC surgery varied among the patients. Additionally, with regard to the overall outcome of patients who died after being discharged from the hospital, the timing of death occurred at different time intervals. Patients who were discharged from the hospital after surgery but passed away before the outcome assessment were categorized into three groups based on the date of death: Patients who died within 1 month after discharge, patients who died between

1-6 months after discharge, and patients who died more than 6 months after discharge. This classification enabled a more comprehensive analysis of the overall outcome (death or survival) and survival time following surgery.

To investigate the factors influencing the overall outcomes, functional outcomes, and verbal outcomes, the patients were divided into different groups based on various factors:

Time interval between symptom onset and surgery: Patients were categorized into two groups, less than 48 hours and more than 48 hours, to examine the impact of this interval on outcomes.

Age Groups: Patients were divided into two categories, less than 60 years old and 60 years old or older, to analyze outcomes across different age groups.

Recombinant tissue plasminogen activator (rtPA) treatment: Patients who received rtPA were distinguished from those who did not.

Statistical Analysis

In this study, factors associated with survival status (death or survival) were analyzed using multivariate logistic regression. Ordered logistic regression analysis was used to evaluate factors related to GOSE, mRS, and ASR.

Table 1: The frequency of qualitative variables and common descriptive statistics for quantitative variables (n=144)

Variable	Subgroups	n (%)
Sex	Male	55 (38.2)
	Female	89 (61.8)
COVID-19	No	122 (84.7)
	Yes	22(15.3)
Age groups	Under 60 years old	79 (54.9)
	Above 60 years old	65 (45.1)
Time	Less than 48 hours	73 (50.7)
	More than 48 hours	71 (49.3)
rtPA	No	124 (86.1)
	Yes	20 (13.9)
Territory of Infarction	rt MCA	64 (44.4)
	lt MCA	56 (38.9)
	Posterior circulation	21 (14.6)
	Missing	3 (2.1)
CSF diversion	No	135 (93.8)
	VP shunt	9 (6.3)
History of stroke	No	119 (82.6)
	Yes	25 (17.4)
HTN	No	84 (58.3)
	Yes	60 (41.7)
DM	No	106 (73.6)
	Yes	38 (26.4)
IHD	No	110 (76.4)
	Yes	34 (23.6)
AF	No	127 (88.2)
	Yes	17 (11.8)
Thyroid problem	No	135 (93.8)
	Yes	9 (6.3)
Dyslipidemia	No	126 (87.5)
	Yes	18 (12.5)
Smoking	No	122 (84.7)
	Yes	22 (15.3)
	Range	**mean±SD**
GOSE	1-8	2.57±2.237
mRS	0-6	4.70±1.854
ASR	0-4	2.67±1.516
GCS	3-14	8.51±2.846
Bleeding	150-2100	694.03±386.458
Midline Shift	0-15	8.02±2.796

rtPA: recombinant tissue plasminogen activator; HTN: Hypertension; DM: Diabetes mellitus; IHD: Ischemic heart disease; AF: Atrial fibrillation; GOSE: Glasgow outcome scale- extended; mRS: modified Rankin scale; ASR: Aphasia severity rating; GCS: Glasgow coma scale; MCA: Middle cerebral artery; VP shunt: Ventriculoperitoneal shunt

The proportional odds assumptions were assessed using the parallel lines test. The significance level was set at 0.05. Statistical analysis was performed using STATA software version 17 (StataCorp LLC, College Station, TX, USA).

Results

This study included 144 cerebral infarction patients who underwent DC. Among them, 22 patients (15.3%) who were discharged alive could not be reached for follow-up. Of the remaining, 122 patients followed up for at least 6 months, 55 (45%) were alive, and 67 (55%) had died. Among the deceased, 47 patients (38.5%) died during hospitalization, and 20 (16.4%) died during the follow-up period. The overall outcome (death or survival) was treated as a qualitative variable, while the functional outcomes were measured using the GOSE and mRS indices, and the verbal performance was assessed using the ASR index. All of which were considered quantitative variables.

Table 1 provides a summary of the subgroups for qualitative variables, along with their frequencies, and presents descriptive statistics for the quantitative variables. The frequency distributions for survival status, GOSE, mRS, and ASR are detailed in the supplementary file, table S1.

In the first stage, univariate analysis was conducted to identify significant variables (Supplementary file: tables S2-S5). Significant variables were then included in multivariate models.

Table 2 presents the results of a multivariable logistic regression analysis, which examined factors influencing the overall outcome (death or survival) of patients. The analysis was based on odds ratios (OR). According to the findings, patients aged over 60 years had a significantly lower chance of survival (OR=0.152) than individuals under 60 years of age. Individuals with a history of stroke were associated with a lower probability of survival than those without such a history (OR=0.227). Patients who had contracted COVID-19 infection demonstrated a lower survival probability than those without the infection (OR=0.164). Additionally, an increase in the GCS score was associated with a higher probability of survival (OR=1.199).

Ordered Logistic Regression

The results of ordered logistic regression analysis, based on OR, for the variables GOSE, mRS, and ASR are presented in tables 3-5. In terms of the GOSE model, patients aged over 60 years had a lower probability of achieving a higher GOSE score than those under 60 years

Table 2: Multivariate logistic regression results for survival status

Variable	Odds ratio	Std. error	P value	95% Confidence Interval
Age above 60 years	0.152	0.079	<0.001	0.055-0.419
Stroke	0.227	0.157	0.032	0.058-0.882
HTN	0.58	0.298	0.289	0.213-1.585
DM	0.319	0.195	0.062	0.096-1.057
COVID-19 diagnose	0.164	0.112	0.008	0.043-0.626
GCS	1.199	0.05	<0.001	1.105-1.302

rtPA: recombinant tissue plasminogen activator; HTN: Hypertension; DM: Diabetes mellitus; GCS: Glasgow coma scale; MLS: Midline shift; MCA: Middle cerebral artery; Reference categories: Age under 60 years, No Stroke, No HTN, No DM, No COVID-19 diagnosis. Multivariate logistic regression analysis, the level of significance was set as P<0.05.

Table 3: Regular logistic regression results for GOSE

Variable	Odds ratio	Std. error	P value	95% Confidence Interval
Age above 60 years	0.185	0.092	<0.001	0.070-0.492
Territory lt MCA	1.080	0.493	0.866	0.442-2.640
Posterior Circulation	3.521	3.708	0.232	0.447-27.741
Stroke	0.353	0.224	0.101	0.102-1.225
HTN	0.401	0.199	0.066	0.152-1.061
DM	0.437	0.249	0.147	0.143-1.338
COVID-19 diagnose	0.106	0.078	0.002	0.025-0.448
MLS	0.928	0.084	0.408	0.776-1.108
GCS	1.177	0.090	0.033	1.013-1.367

HTN: Hypertension; DM: Diabetes mellitus; GCS: Glasgow coma scale; MLS: Midline shift; MCA: Middle cerebral artery; Reference categories: Age under 60 years, Territory (rt MCA), No Stroke, No HTN, No DM, No COVID-19 diagnosis; Regular logistic regression analysis, level of significance was set as P<0.05.

Table 4: Ordered logistic regression results for mRS

Variable (Reference)	Odds ratio	Std. error	P value	95% Confidence Interval
Age above 60 years	5.182	2.551	<0.001	1.974-13.600
Stroke	3.356	2.139	0.057	0.962-11.703
HTN	2.440	1.212	0.073	0.921-6.461
DM	2.678	1.491	0.077	0.899-7.977
COVID-19 diagnose	8.142	5.829	0.003	2.002-33.123
MLS	1.186	0.076	0.008	1.046-1.344
GCS	0.839	0.060	0.014	0.728-0.965

HTN: Hypertension; DM: Diabetes mellitus; GCS: Glasgow coma scale; MLS: Midline shift, Reference categories: Age under 60 years, No Stroke, No HTN, No DM, No COVID-19 diagnosis; Ordered logistic regression analysis, level of significance was set as P<0.05.

Table 5: Ordered logistic regression results for ASR

Variable (Reference)	Odds ratio	Std. error	P value	95% Confidence Interval
rTPA	0.368	0.296	0.215	0.076-1.783
Territory lt MCA	0.027	0.023	<0.001	0.005-0.143
Posterior Circulation	3.230	5.741	0.510	0.099-105.226
MLS	1.045	0.165	0.779	0.767-1.424
GCS	1.354	0.192	0.032	1.026-1.786

rtPA: recombinant tissue plasminogen activator; GCS: Glasgow coma scale; MLS: Midline shift; MCA: Middle cerebral artery; Reference categories: No rTPA, Territory (rt MCA); Ordered logistic regression analysis, level of significance was set as P<0.05.

of age (OR=0.185). Patients diagnosed with COVID-19 were less likely to have a high GOSE score than others (OR=0.106). Conversely, an increase in GCS score before surgery was associated with a higher probability of achieving a better GOSE score (OR=1.177).

The results of ordered logistic regression for the mRS model showed that patients aged over 60 years were more likely to have higher mRS scores than those under 60 years of age (OR=5.182). Additionally, patients diagnosed with COVID-19 had higher mRS scores than others (OR=8.142). An increase in MLS was associated with a higher mRS Score (OR=1.186). Furthermore, an increase in GCS was associated with a lower probability of having a higher mRS score (OR=0.839).

Regarding the ASR model, patients in lt MCA territory involvement had lower odds of achieving a higher ASR score than those with rt MCA involvement (OR=0.027). However, an increase in GCS score was associated with a higher probability of achieving a better ASR score (OR=1.354).

Discussion

Out of 144 cerebral infarction patients undergoing DC, 22 were lost to follow-up. Of the 122 patients who were followed up, 55 (45%) survived, and 67 (55%) died (47 during hospitalization, 20 at least 6 months following DC). The 6-month mortality rate in this study was higher than that reported in similar studies with smaller sample sizes.[18, 24] For instance, a randomized controlled trial of DC with standardized medical care reported a 38.5% mortality rate after 6 months in the surgical group.[25] It has been demonstrated that older patients with cerebral infarction (aged 60 and over) who underwent DC had a lower chance of survival.[14] The higher mortality rate observed in the present study, compared to other studies, could be attributed to the exclusion of patients over the age of 55 or 60 in those studies, which likely contributed to better survival outcomes. Additionally, the exclusion of patients with a history of debilitating neurological deficits or those in poor general health in previous studies might also explain their better survival rates. However, other potential reasons for the differences in mortality rates should be explored in future studies specifically designed to assess factors affecting mortality.

In our study, age over 60 was associated with both lower survival rates and poorer functional outcomes, as reflected in lower GOSE scores, and higher mRS scores. While other studies emphasized better outcomes in patients younger than 60,[13] the findings of the present study underscored the unfavorable mortality and functional outcomes in the older age group. However, from both legal and ethical perspectives, these results require further validation in future studies and should inform healthcare policy decisions to guide treatment strategies for patients over 60.

The present study found no significant difference in survival outcomes between patients who underwent DC within 48 hours and those undergoing the procedure beyond this time frame. Similarly, a systematic review reported no significant difference in mortality between these timeframes, attributing this to the limited number of patients in the ≥48-hour subgroup.[17] However, previous studies recommended early surgery (within 48 hours) for better outcomes.[20, 26-28] These findings highlighted the need for further investigation through multicenter studies and clinical trials to better understand the effect of surgical timing on survival outcomes, as patients might still benefit from surgery even beyond this period.[28]

Due to the prevailing conditions of the COVID-19 pandemic during the time of our study, no similar study has been conducted to assess the effects of COVID-19 on the outcomes of DC in patients with cerebral infarction. Therefore, further research is required to investigate this aspect.

In this study, the functional outcome of patients was assessed at least 6 months after surgery using the GOSE index. Among the 122 patients, 67 (55%) had a GOSE score of 1, indicating death. Of the 55 patients who were alive at least 6 months after DC and had a definite functional outcome, 32 patients (58.18%) had a GOSE score between 5 and 8, indicating moderate to mild disability. It is worth mentioning that most previous studies investigating the functional outcome of DC utilized the mRS criterion.[29]

Additionally, when evaluating the functional outcome of patients based on the mRS criterion, it was found that out of the 122 patients with a specific functional outcome after at least 6 months, 24 patients (19.7%) had a favorable mRS score ranging from 0 to 3. On the other hand, 98 patients (80.3%) had an adverse outcome (mRS scores ranging from 4 to 6). Among the patients with adverse outcomes, 31 patients (25.4%) experienced severe disability (mRS scores of 4 and 5), and 67 patients (55%) died within 6 months (mRS score of 6).

In the HAMLET clinical trial, which involved 32 patients undergoing DC, 75% of patients experienced an adverse outcome based on the mRS index.[30] Similarly, in the DESTINY study, the estimated rate of adverse outcomes based on the mRS after one year was 50%.[31] In the present study, several factors influenced the functional outcome of patients based on the mRS index, including age, COVID-19 infection, and MLS rate. A comparison between the current study and the HAMLET clinical trial revealed that the reason for the lower rate of adverse outcomes in the HAMLET study could be attributed to the inclusion criterion of a GCS score greater than 9.[30] Additionally, the exclusion of patients over 60 years old in the DESTINY clinical trial might have contributed to a higher percentage of favorable functional outcomes in that study.[31]

This research project focused on assessing the verbal outcome of patients using the ASR criterion. Among the 55 patients who were alive 1 year after surgery, 27 patients (49%) did not experience any difficulties in understanding or verbal communication. In contrast, six patients experienced complete impairment in listening, speaking, writing, and overall verbal skills. The present study identified two significant factors influencing the verbal outcome, namely the GCS score before surgery and stroke involvement in lt MCA territory. It is important to note that there are limited studies available on verbal outcomes after DC surgery and its associated factors. Consequently, comparing and analyzing our findings with existing research was challenging. While the verbal outcome of stroke patients has been extensively studied, the specific impact of DC on the verbal outcome requires further investigation, ideally through clinical trials.

Mechanical thrombectomy, the standard treatment for ischemic CVA (which is imposed by large vessel occlusion) was not implemented in our center. Moreover, it is suggested that future studies evaluate the potential effects of rtPA administration on infarction rates and postoperative outcomes. Investigating this variable could provide a more comprehensive understanding of its influence on patient recovery and surgical complications. The findings of this study might be limited to the study center due to its single-center design. Therefore, the results should be further validated in multicenter cohorts to ensure broader applicability.

Conclusion

This study found several factors that significantly influence patient outcomes following DC surgery. Age was identified as an important factor affecting survival, with the chance of survival decreasing as patients' age increased. A history of stroke significantly influenced both survival and functional outcomes, as patients with a previous stroke exhibited higher mortality rates and increased disability. COVID-19 infection was associated with a lower probability of survival post-surgery than non-infected individuals and significantly affected functional outcomes.

The most significant factor influencing both the survival and functional outcomes of cerebral infarction patients who underwent DC surgery was the preoperative GCS score. Higher GCS scores before surgery were correlated with a greater chance of survival rates and better functional and verbal outcomes. Additionally, the study revealed a direct relationship between MLS, measured in mm, and adverse patient outcomes post-surgery.

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Authors' Contribution

M.J and S.G: Conception and design of the work, data acquisition and analysis, interpretation of data for the work; M.N: Conception and design, data acquisition, analysis; E.M.H and A.R: Interpretation of data for the work; M.S: Analysis of data for the work. All authors contributed to drafting the work and reviewing it critically for important intellectual content. All authors approved the final version to be published; and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest: None declared.

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