Original Article

Outcome after decompressive craniectomy in patients with dominant middle cerebral artery infarction: A preliminary report

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Abstract

Introduction: Life-threatening, space occupying, infarction develops in 10-15% of patients after middle cerebral artery infarction (MCAI). Though decompressive craniectomy (DC) is now standard of care in patients with non-dominant stroke, its role in dominant MCAI (DMCAI) is largely undefined. This may reflect the ethical dilemma of saving life of a patient who may then remain hemiplegic and dysphasic. This study specifically addresses this issue. **Materials and Methods:** This retrospective analysis studied patients with DMCAI undergoing DC. Patient records, operation notes, radiology, and out-patient files were scrutinized to collate data. Glasgow outcome scale (GOS), Barthel index (BI) and improvement in language and motor function were evaluated to determine functional outcome. **Results:** Eighteen patients between 22 years and 72 years of age were included. 6 week, 3 month, 6 month and overall survival rates were 66.6% (12/18), 64% (11/17), 62.5% (10/16) and 62.5% (10/16) respectively. Amongst ten surviving patients with long-term follow-up, 60% showed improvement in GOS, 70% achieved BI score >60 while 30% achieved full functional independence. In this group, motor power and language function improved in 9 and 8 patients respectively. At last follow-up, 8 of 10 surviving patients were ambulatory with (3/8) or without (5/8) support. Age <50 years corresponded with better functional outcome amongst survivors (*P* value –0.0068). **Conclusion:** Language and motor outcomes after DC in patients with DMCAI are not as dismal as commonly perceived. Perhaps young patients (<50 years) with DMCAI should be treated with the same aggressiveness that non-DMCAI is currently dealt with.

Key Words

Craniectomy, dominant, middle cerebral artery, outcome, stroke

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Introduction

Life-threatening space occupyfing infarction may develop in 10-15% of patients after middle cerebral artery infarction (MCAI).[1,2] Conservative management is associated with high mortality rates approaching 80%,[3,4] which has resulted in a re-evaluation of the role of medical therapy in this condition.[2,5-9] Decompressive craniectomy (DC), which involves removal of a large bone flap and duroplasty, has been proposed as a life-saving procedure with a positive impact on functional outcome in survivors.[3,10-13] Though level I evidence now exists to support the results of these studies,[14-16] the data is biased toward the evaluation of patients with a non-DMCAI. This may reflect the reluctance of surgeons and family members to save the life of a patient with a dominant MCAI (DMCAI) who may survive only to remain hemiplegic and dysphasic.[12,17] This is a compelling ethical consideration as post-surgical survivors may be left severely disabled as hemiplegia and global dysphasia is considered to be the severest form of neurological disability. Unsurprisingly, global aphasia was an exclusion criterion in two studies.[9,13]

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Literature regarding DC in patients with DMCAI suffers from an additional lacuna in that language function has not been adequately addressed. Whether heroic surgical intervention is ethically justifiable in this subgroup of patients in terms of improvement in motor, language, and functional outcome has not been clearly elucidated thus far. The present study attempts to address this issue.

Table 1: Review of literature. Studies with ≥10 patients with DMCAI

Author	Year	Total no.	No. with DMCAI
Schwab *et al.*[13]	1998	63	11
Pranesh *et al.*[29]	2003	19	10
Uhl *et al.*[33]	2004	188	63
Malm *et al.*[27]	2005	30	14
Pillai *et al.*[28]	2007	26	12
Present study	2012	18	18

DMCAI: Dominant middle cerebral artery infarction

A careful review of literature, to the best of our knowledge, indicates that a total of 165 surgically treated patients with DMCAI have been reported in the literature until date.[9-11,13-35] However, only 5 series have cohorts ≥10 patients [Table 1]. This series, therefore, is the 2nd largest of its kind in published literature and even exceeds the destiny trial number.[16]

Materials and Methods

This was a retrospective analysis performed at a tertiary care neurosurgical center at a National University Hospital. Patient records, operation notes, radiology, and out-patient files were scrutinized to collate data.

Patient selection

All consecutive right handed patients with a DMCAI who were admitted at our institute and underwent a DC were included in the present study. These patients had evidence of either clinical or radiological deterioration in the pre-operative post-admission period or a space occupying infarction on the presenting CT scan with midline shift >5 mm, mass effect on the ipsilateral ventricle and effaced basal cisterns.

Patient evaluation

At admission, patients were clinically evaluated and the Glasgow coma scale (GCS), dysphasia and extent of right hemiparesis were recorded as were the post-operative changes in these variables. The duration Glasgow outcome scale (GOS),[22] Barthel index (BI),[36] type of dysphasia and extent of right hemiparesis were also recorded at the time of discharge and at last follow-up. Motor power was assessed as per the Medical Research Council (MRC) scale.

BI was used to rate physical disability in terms of ambulation and self-care.[36] A patient having a score of 100 was able to perform activities of daily living without assistance. A score of less than 60 implied severe disability and functional dependence while that between 61 and 95 indicated mild to moderate disability. A score of 60 was held to be a watershed as patients below this score were functionally dependent, whereas those above it were independent, but with assistance.[37] Among the 10 patients who were followed-up, 7 were examined in the clinic follow-up and 3 were telephonically interviewed. Assessment of motor power, ambulatory status, language function, and measurement of GOS and BI was carried out in all patients. In patients who were telephonically interviewed, description by relatives or the patient him/herself, of the activities performed by patient, was used as a guide to determine motor power. Talking to patient on telephone helped in assessing language function. Questions were asked from patient as well as relatives to determine extent of physical activities performed and dependence on others for activities of daily living. Standard questionnaire of BI was used in all patients.

Operative methods

All patients were operated under general anesthesia. A broad based, question mark, scalp flap centered on the superficial temporal artery was used. Subsequently, a free left fronto-temporo-parietal bone flap was raised. The lesser wing of the sphenoid and the basitemporal bone were then rongeured until the middle cranial fossa floor. The dura was incised in a curvilinear fashion, based on the lesser sphenoid wing, and radial incisions were made from the convexity of this incision. Use was made of the pericranium/temporalis fascia to augment the dura. None of the patients underwent lobectomy/infarctectomy. The bone flap was placed in a subcutaneous pouch in the anterior abdominal wall.

Follow-up

Patient outcome was evaluated using hospital records, discharge summaries, out-patient notes, scheduled physical examination, and telephonic interviews. The variables evaluated in this cohort have been mentioned in an earlier section.

Statistical analysis

Data were presented as numbers (%) or mean/median (range) as appropriate. Patient characteristics such as age, sex, GCS at admission, comorbidities, and time interval between ictus and surgery were compared between patients who survived and those who died using the Wilcoxon rank sum test/Fisher's exact test. The correlation between age and BI and GOS was made using Spearman's rank correlation. A P value less than 0.05 was considered statistically significant. Statistical analysis was carried out using the STATA 9.0 (College Station, Texas, USA).

Results

A total of 18 patients with DMCAI infarct undergoing DC between November 2005 and September 2009 were included in this study. The demographic characteristics of the patients are shown in Table 2. The GCS at admission ranged from 4 to 11 with a mean and median of 8.6 and 9 respectively. Pre-operatively, all the patients had right sided weakness. Eleven patients were hemiplegic while the remaining 7 patients had <3/5 MRC power in the right upper and lower limbs [Table 3].

The mean time interval between the onset of symptoms and surgery was 66.1 h with a range of 9 h-6 days. Out of 18 patients, 6 patients (33.3%) died during the in-hospital stay at a median interval of 11 days after the ictus. Twelve patients were discharged home, of whom one patient expired within 3 months. 1 patient was lost to follow-up after discharge and was excluded from further analysis. The rate of survival at 6 weeks after surgery was 66.6% [Table 2].

Characteristics of patients who expired

Six patients expired during their hospital stay. The demographic characteristics of the patients are shown in Table 3. The mean pre-operative GCS was 8.7 (range: 6-10). 4 patients had pupillary asymmetry, which was recorded at the time of presentation. 2 patients were hemiplegic and 4 had hemiparesis with <3/5 MRC power in the right upper and lower limbs [Table 3].

Table 2: Patients characteristics

Characteristics	Value
Total number of patients	18
Mean age in years (range)	48 (22-72)
Male:Female ratio	2:1
Co-morbidities	
Hypertension	5
Hypertension and diabetes	1
RHD	1
RHD with HC	1
Mean GCS at admission (range)	8.6 (4-11)
Mean time in hours to surgery (range)	66.1 (9-144)
Number of patients discharged	12
Rate of survival (6 weeks)	12/18 (66.6%)

GCS=Glasgow coma scale, RHD=Rheumatic heart disease, HC=Homocystinemia

Table 3: Characteristics of discharged and expired patients

Patients	Total	Discharged	Expired in-hospital
Number	18	12	6
Gender	M-12; F-6	M-9; F-3	M-3; F-3
Mean age (years)	48	45.4	53.3
Co-morbid conditions	8	5	3
GCS at admission (mean)	8.6	8.5	8.7
Pupillary asymmetry (%)	6 (33.3)	2 (16.7)	4 (66.7)
Power <3/5 MRC at admission	18	12	6
Mean ictus-surgery time (hours)	66.1	70.9	56.7
Post-op. ventilation (days)	9.1	6.5	14.3
Mean hospital stay (days)	21.2	24.6	14.3

None of the variables approached statistical significance. GCS=Glasgow coma scale, MRC=Medical Research Council

Time interval from ictus to surgery in this cohort ranged from nine to 120 h with a mean of 56.7 h. The mean best post-operative GCS achieved in these patients was 6.5 (range: 3-11). The average post-operative survival in these patients was 14.3 days (range: 4-40). Out of 6, 5 patients expired within 2 weeks [Table 3]. Two of these patients died due to sepsis and in the rest four, death occurred due to raised intracranial pressure.

Characteristics of patients who were discharged

Twelve patients were discharged from hospital after surgery. The demographic characteristics of the patients are shown in Table 3. The mean pre-operative GCS was 8.5 (range: 4-11). 8 patients were hemiplegic. The remaining 4 patients had hemiparesis with <3/5 MRC power in the right upper and lower limbs [Table 3].

Time interval from ictus to surgery ranged from 24 h to 144 h with a mean of 70.9 h. The duration of post-operative ventilation among these patients ranged from 1 day to 20 days with a mean duration of 6.5 days. The mean duration of hospital stay was 24.6 days (range: 7-45 days) [Table 3].

The GOS at the time of discharge was 3 in all patients except one patient who had a GOS of 4 at the time of discharge. All patients had a BI < 60 at the time of discharge [Figure 1a]. All patients were dysphasic; 7 patients had global aphasia and 5 patients had gross motor dysphasia. 8 patients were hemiplegic and 4 patients had <3/5 MRC power in their right upper and lower limbs. One patient was lost to follow-up after discharge. One patient expired at home at about 3 months after discharge due to renal failure. Thus, 10 patients were available for follow-up. The mean follow-up period in these 10 patients was 19 months (range: 8-24) [Table 4].

Survival

Six week, 3 month, 6 month and overall survival rates in our study were 66.6% (12/18), 64%(11/17), 62.5% (10/16), and 62.5% (10/16) respectively. Amongst patients who were discharged, the mortality rate was 8.3% as a single patient (1/12) expired after discharge.

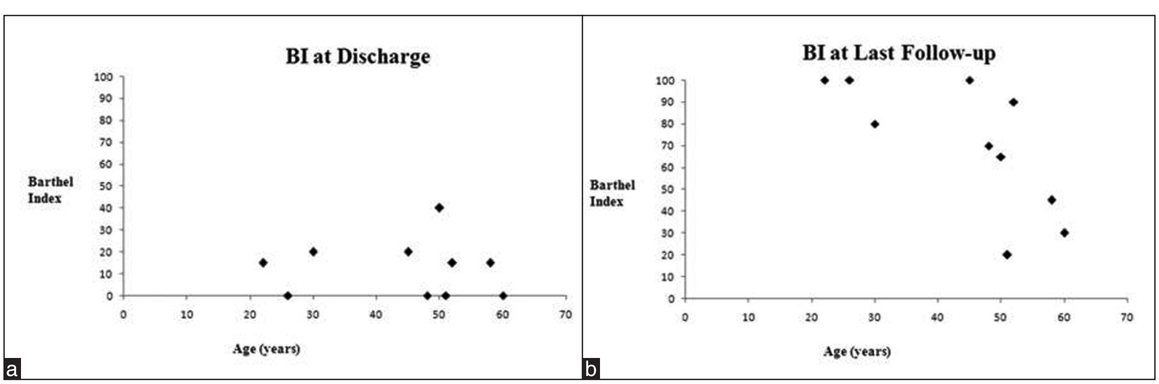

Figure 1: Scatter diagram indicating the Barthel index at discharge (a) and at last follow-up (b)

Table 4: Characteristics of patients discharged from hospital

S. no.	Age (years)	Post-op. ventilation (Hours)	Follow-up (months)	GOS-at discharge	GOS-at 3 months	GOS-last F/U	BI-at discharge	BI-at 3 months	BI-at last F/U	Dysphasia at discharge	Dysphasia at last F/U	Power at discharge	Power at last F/U	Ambulatory status at last F/U
1	22	54	18	3	3	4	15	40	100	Motor	Motor	0/5	4/5	Walking without support
2	26	48	8	3	4	5	0	70	100	Motor	None	0/5	4/5	Walking without support
3	30	48	24	3	3	4	20	40	80	Global	Mild motor	2/5	4/5	Walking without support
4	45	144	40	3	3	4	20	40	100	Motor	Mild motor	1/5	4/5	Walking without support
5	48	64	8	3	3	4	0	35	70	Motor	Mild motor	0/5	3/5	Walking with support
6	50	144	9	3	3	3	40	40	65	Global	Motor	0/5	3/5	Walking with support
7	51	48	16	3	3	3	0	15	20	Global	Mild motor	0/5	0/5	Bedridden
8	52	48	14	3	3	4	15	15	90	Global	Motor	0/5	4/5	Walking without support
9	58	24	14	3	3	3	15	15	45	Global	Motor	2/5	3/5	Walking with support
10	60	144	40	3	3	3	0	15	30	Global	Global	0/5	1/5	Bedridden
*11	58		3	3	3	–	15	15	–	Motor	–	1/5	–	–
#12	45		2	–	–	–	0	–	–	Global	–	0/5	–	–

GOS=Glasgow outcome scale, BI=Barthel index, F/U=Follow-up. *Expired at home after 3 months, #Lost to follow-up

Functional outcome

During the follow-up, 6 patients (60%) noted an improvement in GOS (five patients had a GOS of 4, one patient had a GOS of 5 and 4 had a GOS of 3. None of the patients had GOS <3 [Table 4].

The mean BI (of the 10 patients still under follow-up) at the time of discharge was 11.6 (median BI – 15; range 0-40). The mean BI at the last follow-up was 70 (median BI – 75; range 20-100). BI improved to >60 in 7 patients at last follow-up [Figure 2]. Three patients were functionally independent with a BI of 100 at last follow-up. 4 patients had achieved a state of assisted independence (BI 61-95) while the remaining 3 patients had BI <60 and were functionally dependent. None of the patients was in a vegetative state [Table 4].

Language outcome

Out of 10, 6 patients under follow-up had global dysphasia at the time of discharge while the remaining four had motor dysphasia. All patients (83.3%) except one with global dysphasia had improvement in language function. Two of the six patients with global dysphasia had started speaking fluently with an occasional difficulty in verbalizing. The remaining three patients were able to comprehend normally, but had no verbal output. A single patient had no improvement in language function.

In 4 patients with motor dysphasia, 1 patient had started speaking near normally, 2 patients had shown significant improvement and one patient had persistent gross motor dysphasia [Table 4, Figure 3] at last follow-up.

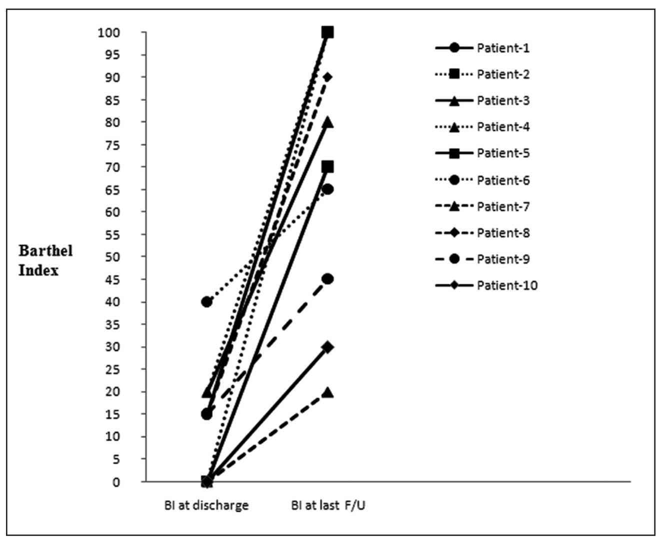

Figure 2: Graph indicating the individual improvement in the Barthel index amongst survivors at last follow-up

Motor outcome

At last follow-up, power in the right upper and lower limbs improved in 9 of 10 surviving patients (90%). One patient remained hemiplegic. In 5 patients, power improved to 4/5 MRC and they had started walking without support. Three patients could walk with support. Two patients were bedridden [power <3/5 MRC; Table 4].

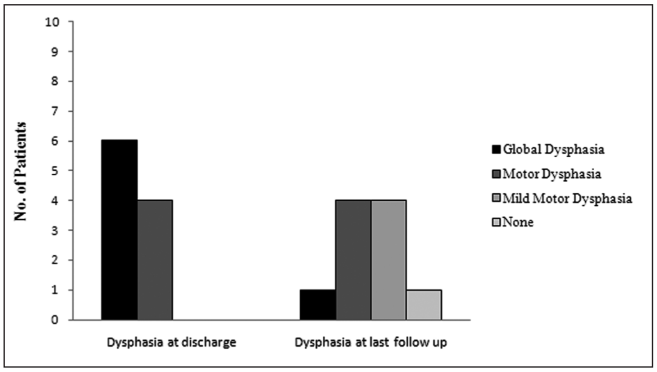

Figure 3: Bar diagram revealing the type of dysphasia at the time of discharge and last follow-up

Overall outcome and positive predictors in survivors (*n* = 10)

At the time of last follow-up 62.5% (10/16) of the cohort were alive. Among 10 patients who had long-term follow-up, 60% showed an improvement in GOS, 70% achieved a BI score >60 with 30% having a BI score of 100/100. Of the survivors, 80% showed improvement in language function, 90% showed improvement in power in right upper and lower limbs and 80% were ambulatory, with (30%) and without (50%) support.

Demographic and clinical characteristics were compared between those patients who died during in-hospital stay and those discharged from the hospital. There was no statistically significant difference in terms of age, gender, and presence of co-morbidities, pre-operative GCS and time interval between ictus and surgery between these subgroups.

Among patients who were discharged, a statistically significant correlation was seen between the age of patient and functional outcome. Younger patients (<50 years) had better BI (*P* value −0.0068) and GOS (*P* value −0.0137) scores at last follow-up [Figure 1b]. All 6 patients, younger than 50 years in age, achieved a BI >60 score and started walking (two with and four without support). Only one of four patients older than 50 years achieved this functional outcome [Table 4]. Five of these ten patients subsequently underwent cranioplasty.

Discussion

Malignant MCAI is associated with high mortality and morbidity. Mortality rates, with conservative treatment alone, approach 80%.[3,4] DC, though not a recent concept, has recently gained popularity in the management of MCAI.[10-13] This follows the documentation of the impressive life-saving effect of this procedure in randomized controlled trials.[14-16,34]

In patients with DMCAI; however, life-saving interventions are generally avoided for fear of leaving a surviving patient in an unacceptably poor functional state. A selection bias in favor of operating on non-DMCAI can be seen in a majority of the studies addressing the role of DC in this condition.[9,13,17-19,21,25,26,31,33,35] This reflects an obvious reluctance to be aggressive in the DMCAI subgroup of patients.

Evaluation bias

Over the past few years, this trend has been changing. Authors have included patients with DMCAI in studies evaluating the role of DC and have found that these patients have survival rates and functional outcomes no different from patients with non-DMCAI using the modified Rankin score (mRS) and BI.[15,34]

This counters intuitive reasoning and may reflect an evaluation bias. It is unarguable that language function improvement is a vital component to vindicate the use of DC. Functional outcome assessment in terms of language function is lacking in these studies which use the mRS, BI, and GOS scales. This may account for the conclusion that dominant and non-DMCAI have equivalent functional outcomes following DC.[34] We believe that this is incorrect. It is not possible to compare outcome when one patient has a language disorder, whereas the other does not. We have addressed this issue by broadly grading dysphasia as global, motor (complete and partial), and sensory (complete and partial). This has also been used by Asil *et al*.[38]

Only one study has used an extensive language function analysis, but this study[39] has the disadvantage of being highly selective in that the assessment was a one-time study performed several months after surgery. Complicated neurolinguistic tests also render any comparison meaningless as the initial scores are generally very low or impossible to assess due to poor attention/vigilance and intubation. This selection bias also skews outcome analysis to indicate a highly favorable result as those patients with a significant recovery only are naturally included. Our study, on the other hand, offers an insight into the dynamic changes that occurs following language recovery after DC.

Patient survival

Of 18 patients included in the study, 12 (66.6%) were discharged from the hospital. These discharged patients had a survival rate of 83.3%. This is slightly lower as compared to previous studies. The reasons for this difference could be the longer time interval between ictus and surgery (66.1 h mean).[5,13] The mean time interval between ictus and surgery was <6 h and 21 h respectively in studies performed by Cho *et al*,[5] and Schwab *et al*,[13] respectively. The time interval between ictus and surgery has also been shown to be an important variable affecting the outcome in patients with malignant MCAI.[5,13,18,25]

Another explanation could be the age factor. Age is an important prognostic factor in patients with MCAI undergoing DC and studies have consistently reported the negative effect of increasing age on survival rates in these.[18,19,21,24,26,35] In our study, the overall mean age was 48 years, but the mean age of patients who expired was 53.3 years. Our study, perhaps because of small numbers, could not replicate the beneficial effect of early surgery or younger age on survival.

Though, the duration of post-op ventilation was longer in patients who died this was not statistically significant. As these patients were also older, had a paradoxically shorter time to surgery and had a greater incidence of pupillary asymmetry [Table 3], it is our hypothesis that the presumed cause of death may have been a greater primary neurological insult. This may explain why survivors could all be weaned off mechanical ventilation while patients who expired could not be. However, in patients, who did survive, age less than 50 years was shown to be a favorable prognostic factor predicting favorable functional outcome. All patients ≤50 years of age (100%) became functionally independent with (50%) or without (50%) assistance, whereas only one patient (25%) older than 50 years achieved a state of assisted independence [Table 4]. Leonhardt *et al*,[26] have reported similar results. In their study, patients older than 52 years had a BI of 50 or below while younger patients had a better outcome.

One of the shortcomings of this study was the inability to correlate survival with infarction volumes and medial temporal lobe ischemia. This is a retrospective study. Unfortunately, we were unable to access radiological images of 10 patients as there were technical issues with retrieval from the archiving system.

Language function

Most discussions about DC in MCAI are limited to patients with non-dominant stroke. Though studies have addressed the beneficial role of DC in DMCAI, these mostly detail survival and functional outcome in terms of BI/mRS, rather than the recovery of language function.[23,28,29,38,39]

Kalia and Yonas[23] reported the role of surgery in four patients with MCAI, of which two had DMCAI. Both patients had global dysphasia and right hemiparesis pre-operatively. One of the patients was able to communicate in short phrases and became functionally independent 2 years after surgery. The other patient had full comprehension and motor dysphasia 3 years after surgery and achieved functional independence. Pranesh *et al*,[29] studied nineteen patients with MCAI undergoing DC out of which ten had DMCAI. They reported good recovery in all patients with dysphasia. However, the type of dysphasia and the nature of recovery of language function in individual patients were not elaborated.

Kastrau *et al*,[39] reported recovery from aphasia in 13 of 14 patients with large hemispheric infarctions after decompressive surgery. However, the study was performed by a neurolinguistic center, and patients were first evaluated 538 days (ranges from 105to 1207 days) after the decompressive surgery. Pillai *et al*,[28] included 12 patients with DMCAI in their study of 26 patients. Nearly, 50% of these patients survived; among these 5 (83%) had moderate to severe motor dysphasia at 6 months and 12 months and one had fluent speech with only deficits in naming and repetition.

In our study, overall, 80% (8/10) of the survivors improved in their language function. Among patients with global dysphasia, 33% (2/6) started speaking normally while 50% gained comprehension with partial improvement in motor speech (3/6). In 4 patients with motor dysphasia, 3 (75%) recorded an improvement in language function.

Conclusions

Our study was designed with the specific aim of providing neurosurgeons and attending neurophysicians with the data to realistically prognosticate out-come after DC in patients with DMCAI. The out-come is not as grim as would be expected. With a 66.6% discharge rate, 58.8% overall survival rate, 70% chance of achieving assisted independence (BI >60), 30% probability of achieving full functional independence and 80% improvement in language function, we feel that a subset of patients younger than 50 years of age should be treated with the same aggressiveness that non-DMCAI is now dealt with.

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