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RESEARCH ARTICLE

ANALYSIS OF OUTCOME OF DECOMPRESSIVE CRANIECTOMY IN PATIENTS WITH ACUTE MASSIVE CEREBROVASCULAR ACCIDENTS – AN INSTITUTIONAL ANALYSIS

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ABSTRACT

Aims: The overall aim was to evaluate the outcome of decompressive craniectomy (DC) in patients with acute massive cerebrovascular accidents in a tertiary referral center with the primary outcomes being survival, functional ability and psychosocial consequences.

Methods: The study was a retrospective study over the last four years. Data derived from case sheets, reports and operative notes. The main outcome measures were noted from Glasgow Scale (GCS), National Institutes of Health Stroke Scale (NIHSS), Barthel Index (BI), and Modified Rankin Scale (MRC).Changes over time during follow-up were obtained by telephonic communication with patient. Analysis was done using a statistical method that is suitable for small data sets.

Results: The retrospective data was analyzed for a period of four years, of which 51.11% patients had ischaemic stroke and 48.89% had intracranial hemorrhage respectively. All patients who underwent decompressive craniectomy survived and did well with the surgery 85.07% people improved to MRC scale of 3 and 14.93% patients expired due to secondary causes such as MI aspiration pneumonia etc which occurred duringhospitalization. The therapeutic algorithms, time to tracheotomy time to cranioplasty were also noted. The control group who received only medical management saw only 1.5% survival.

Conclusions: The studies show that an effective chain of medical surgical and rehabilitation activities can produce a good outcome/living situation and that life can be satisfactory for patients after massive cerebrovascular accidents in spite of neurological deficits.

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INTRODUCTION

Cerebrovascular accident (CVA) is a medical emergency and the most common affection of the central nervous system (CNS). This is the second-leading cause of death worldwide and the first cause of morbidity (Murray *et al.,* 1997). Ischemic stroke correspond to 85% of all strokes and remaining haemorrhagic with a mortality of 10-50%.Large space-occupying Cerebrovascular accidents accounts for 1-10% of them with signs of elevated intracranial pressure (ICP) and brain hernia ion usually within maximum of 2 days leading to a mortality rate of 53% to 89% (Holtkamp *et al.,* 2001; Kuroki *et al.,* 2001; Rieke *et al.,* 1995; Vahedi *et al.,* 2007). The high mortality rate makes some authors call these strokes as "malignant" to describe the rapid development of fatal brain swelling. Large space-occupying cerebrovascular accidents are generally secondary to an occlusion or rupture of the carotid artery or the M1 segment of the middle cerebral artery (MCA), (sometimes involvement of MCA + ACA or MCA + PCA) Neuroimaging criteria varies between the authors: infarct volume on diffusion-weighted magnetic resonance imaging (MRI) of more than 145 cm^3; hemorrhage >10 cm^3 in volume; brain computed tomography (CT) ischemic/ haemorrhagic changes affecting more than two-thirds of the MCA territory and including the basal ganglia; brain CT ischemic changes affecting at least two-thirds of the MCA territory with space-occupying edema; signs on CT of an infarct/haemorrhage of at least 50% of the MCA territory, with or without additional infarction in the territory of the anterior or posterior cerebral artery on the same side (Vahedi *et al.,* 2007; Hofmeijer *et al.,* 2006; David Mendelow *et al.,* 2013).

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Many studies have suggested that decompressive surgery, consisting of a hemicraniectomy and duraplasty, reduces mortality and improves outcome in patients with massive brain infarctions. We report our series of 135 patients of whom 69 were treated with decompressive craniectomy and 66 were managed medically.

MATERIALS AND METHODS

Study design

In this retrospectively designed study, we describe the results of decompressive hemicraniectomy in 69 patients with large hemispheric infarctions large ICH and large CVT's from january 2010 to june 2014.We have considered massive cerebral infarction, haemorrhages and CVT's with brain CT affecting at least two-thirds of the MCA territory with space-occupying edema or both MCA and ACA or PCA regions leading to a minimum of 50% hemispherical volume compromised. We analyzed gender, age, Glasgow Scale (GCS), National Institutes of Health Stroke Scale (NIHSS), Barthel Index (BI), and Modified Rankin Scale (MRC) on admission, pre-surgical evaluation, post op length of stay in the hospital and outcome 6 months after discharge. There was a control group of 66 patients who didn't undergo decompressive craniectomy as a result of refusal of consent for surgery/arriving late to hospital. Data was subsequently analyzed for comparative study of patients with good to moderate outcome and patients with poor outcome.

Surgical technique

A standard fronto tempero parietal decompressive craniotomy was performed on the affected side. If the CVA was haemorrhagic clots were evacuated.

Patient selection

The decision to perform decompressive craniectomy was based on the presence of a space-occupying large cerebrovascular accidents on CT scan and the clinical status of the patients. Patients with GCS >13,Barthel Index >30,MRC ≤3,NIHSS scale 14-18 and no midline shift or basal cistern compression at initial evaluation were managed in the intensive care unit. Neurological deterioration or development of brain herniation signs were indications to decompressive craniectomy. Patients initially presenting with GCS ≤8, Barthel index ≤5, MRC ≤5, NIHSS Score≥30 and cistern compression or midline shift at CT scan were taken up for decompressive craniectomy. The control group of patients presenting later than 24 hrs with signs of severe cerebral herniation signs and respiratory depression were not taken up for surgery as per evaluation by both neurologist and neurosurgeon. They were managed medically with artificial ventilation, osmotherapy, and other supportive management. The patients in both groups were taken up for tracheostomy as per need by 10th day.

RESULTS

135 patients (98 males and 37 females) with mean age 50±12, presenting with acute massive cerebrovascular accidentswere collected from retrospective analysis spanning 4 years (2010-2014).In this group 69 patients underwent decompressive craniectomy and remaining 66 patients were managed conservatively (table 1 &2).

Risk factors	Decompression group n-69	Non decompressed group n-66
Diabetes mellitus	26	28
Systemic hypertension	35	37
Cardiac disease	15	12
Others (vasculitis)	3	0
Smoking	30	25
Alcoholism	33	35

Table 1. Age Sex distribution of patients presenting with acute massive cerebrovascular accidents

Age	Male	Female	Total	Percentage %
21-30	12	3	15	11.11
31-40	12	1	13	9.63
41-50	23	4	27	20
51-60	24	13	37	27.41
61-70	19	7	26	19.26
71-80	7	7	14	10.37
81-90	1	2	3	2.22
	98	37	135	
	72.6%	27.4%		

56 of 66 patients who were treated conservatively had late presentations with signs of severe cerebral herniation suggesting poor outcome on assessment by neurologist and neurosurgeon; and 10 of 66 patients refused consent for surgery. 69 patients (mean age 50 ±12)underwent decompressive craniectomy with GCS ≤8, Barthel index ≤5, MRC ≤5,NIHSS Score≥30 and cistern compression or midline shift at CT scan.Patients who presented with scores intermediate between inclusion and exclusion scores showed rapid deterioration to inclusion scores within 24 hours /prior to operation.

Table 2. Incidence of acute massive ischemic, Haemorrhagic and CVT with refernce to type of management(figz1)

Type of cva	Decompressive Craniectomy		Decompressive Craniectomy not done	Total	Percentage %
Ischemic	34	6 expired	35	69	51.11
Haemorrhagic	35	4 expired	31	66	48.89
Total	69	10 expired(6 due to aspiration pneumonia,4 of sepsis,1 of myocardial infarction	66	135	
		51.11%	48.89%		

Table 3.Comparitive outcome of Decompressive Craniectomy and Piatients in whom Medical Mangement was taken up(figz2)

Type of mangement	Alive	Dead	Total N -135	Precentage alive %
Decompressive craniectomy	59	10	69	85.51
Decompressive craniectomy not done	1	65	66	1.5
Total	60	75	135	
Percentage %	44.44	55.56		

With reference to previous studies patients were taken up for surgery within the first 24 hours of presentation after assessing the neurological and cardiac status. The patients showed improvement to GCS≤8 Barthel Index ≤10 MRC ≤4 and NIHSS Score 22 in post op stage; GCS≤10 Barthel Index ≤30 MRC ≤4 and NIHSS Score 20 at time of discharge andGCS≤12 Barthel Index ≤50 MRC ≤3 and NIHSS Score 14 at 3 months and GCS≤12 Barthel Index ≤65 MRC ≤3 and NIHSS Score 10 at 6months follow up.

Table 4. Comparitive outcome of Decompressive Craniectomy and Piatients in whom Medical Mangement was taken up(figz2)

	Alive	Dead	Total	Percentage %
Tracheostomy by 10th day	47	4	51	73.91
Tracheostomy not done	12	6	18	26.09
	59	10	69	
	85.50%	14.5%		

Of the 69 patients with massive infarction 3 patients had massive venous strokes.34 patients in the ischaemic group underwent decompressive craniectomy; and in these 19 patients had involvement of dominant lobe. In the haemorrhagic group 35 of 66patients were taken up for surgery and in this 21 had dominant lobe involvement. The involvement of dominant lobe did not show any significance with reference to improvement. Of the remaning 66 patients 35 patients had ischaemic stroke and 31 had haemorrhagic stroke.

not receive early tracheostomy within the first 10 days. The assessment of the study showed majority of the patients who received early tracheostomy (47 ischaemic and 12 haemorrhagic) showed better outcome as tracheal toileting and reduction of anatomical dead space contributed to better perfusion of lung (Table 4).

DISCUSSION

Patients with massive space-occupying hemispheric cerebrovascular events have a poor prognosis, as mass effect usually develops rapidly with occurrence of clinical deterioration within maximum of the first 48 hours (Vahedi *et al.,* 2007; Kilincer *et al.,* 2005; Schwab *et al.* 1998; Zuccarello *et al.,* 1999). Decompressive surgery has been studied as a way to relieve the intracranial hypertension and tissue shifts related to mass lesions. Bendszus *et al.,* 2003 reported in his study, analyzing perfusion CT before and after decompressive craniectomy showed the value of this procedure to spare the ischemic penumbra (Bendszus *et al.* 2003).

Non-randomized studies suggest that early and late decompressive surgery reduces mortality and increases the number of patients with a favorable functional outcome after massive hemispheric CVA compared to the conservative treatment (Rieke *et al.* 1995; Vahediet *et al.* 2007; Gupta *et al.* 2005; Schwab *et al.* 1998; Mori *et al.* 2004; Auer *et al.,* 1989).

Table 5. Table of legends

Paper	Type of study	Patients	Decompressive craniectomy	Conservative management	Mean age	Deathin dc %	Death in conservative mangement %
Rieke *et al.* (1995)	P +r	53	32	21	49	34	76
Holtkamp *et al.* (2001)	R	24	12	12	65	33	83
Kuroki *et al.* (2001)	R+p	15	8	7	72	12	85
Vadehi *et al.* (2007)	R	93	51	42	45	22	71
Stich (2005)	R	400	248	152	52	52	68
Stich (2013)	R+p	601	307	294	48	41	62
Juvela *et al.* (1989)	R	56	28	28	45	42	88
Zuccarello *et al.* (1999)	P	38	20	18	52	22	83
Auer *et al.* (1989)	R	100	50	50	60	14	80
Batjer *et al.* (1990)	R	21	13	8	54	30	74
Present study	R	135	69	66	55	14.5	99

R-retrospective study P- prospective study

They were not taken up for surgery due to reasons mentioned earlier (table 2). All patients were given antioedema measures and adequate ventilation in addition to other necessary supportive measures.10 patients who underwent successful decompressive craniectomy expired due to secondary causes (aspiration pneumonia/sepsis/myocardial infarction). In the group where decompressive craniectomywas deferred one patient with a Haemorrhage survived. This could be attributed to elderly age of the patient with significant cerebral atrophy on CT. (Table 3). The mean stay in ICU for patients who underwent decompressive craniectomy was 14±4days,and the total hospital stay spanned to 24±5 days due to early intervention within first 24 hours. Secondary causes of death in patients who underwent decopressive craniectomy were assessed and it showed major factor of death as aspiration pneumonia (6 cases), followed by sepsis (3 cases) and myocardial infarction (1 case). Aspiration pneumonia was identified as significant contributor to mortality in this study following a successful procedure, these patients who died did

Early decompressive surgery with duraplasty is related with even a better outcome (Kilincer *et al.,* 2005; Mori *et al.* 2004; Batjeret *et al.,* 1990). Several conservative measures have been proposed to limit brain tissue shifts and reduce intracranial pressure, including intensive care therapy, mild bed elevation, sedation, hyperventilation, osmotic therapy, hypothermia and others. However, conservative treatment for massive CVA's has been reported (Table5) with a high mortality rate and poor outcome despite all those measures, suggesting that they are of limited value[6,13,14].This is evident in 66 of our patients were the mortality was 100% despite maximal medical management. The three randomized trials, DECIMAL, DESTINY and HAMLET confirm these findings. DECIMAL and DESTINY were interrupted because of a significant difference in mortality favoring decompressive surgery and HAMLET study showed improvement in condition if operated by maximum of 48 hours (Vahedi *et al.* 2007; Hofmeijer *et al.,* 2006; Jüttler *et al.,* 2007; Vahedi *et al.,* 2007). Surgical treatment for intracranial hemorrhage according to outcomes in published studies are conflicting. The international multicenter Trial in Intracerebral Haemorrhage (STICH), which compared early surgery with initial conservative treatment, failed to demonstrate a surgery-related benefit (Haemorrhage, 2005 Mendelow *et al.,* 2005). Analysis of trials for surgical treatment of spontaneous intracerebral hemorrhage found evidence for improved outcome with surgery if the following applied:

- Surgery undertaken within 8 hours of event
- Volume of the hematoma 20-50 mL
- Glasgow coma score 9-12
- Patient age 50-69 years

In addition, evidence suggests that a subset of patients with lobar hematoma but no intraventricular hemorrhage may benefit from intervention. A study in this group of patients (STICH II) has been completed showing 62% death in non intervention and 41% death in patients who underwent surgery (David Mendelow *et al.,* 2013). Our study shows that patients decompressed within 24 hours showed extremely favorable outcome. The risk factors analysed didn't throw light in any significant direction with regard to outcome or incidence of massive cerebrovascular accidents in this study or any other study. Decompressive surgery increases the probability of survival from 25% to nearly 70%. Regarding quality of life after decompressive surgery for massive CVA's, even patients with aphasia may improve significantly. The present study didn't show any variability with regard to involvement of dominant lobe in the outcome.

It is unclear which groups of patients benefit most from the procedure. Vahedi *et al.,* 2007 demonstrated that surgery was beneficial (p<0.01) independently of age (above and below 50 years), presence of aphasia, and time to randomization (above and below 24 h) when compared to conservative treatment. Kuroki *et al*., 2001 found that the decompressive surgery outcome is better than the conservative treatment even in patient with more than 70 years of age. Patients with the larger infarctions as found in the internal carotid artery (ICA) infarct were more likely to have a poorer prognosis as expected and according to Kilincer *et al.,* 2005. Surgery for an ICA infarction is not beneficial, unless exceptional cases as very young age, non-dominant hemisphere, and good clinical condition. Juvela *et al.,* 1989 were able to demonstrate that surgery in patients <65 years with haemorrhagic infarct benefitted from early intervention. (Juvela *et al.,* 1989; Auer *et al.,* 1989) recorded that surgical intervention in massive ICH was independent of age (Auer *et al.,* 1989).

Identification of patients at high risk of malignant edema based on radiographic and clinical criteria might allow early hemicraniectomy, defined as a surgery performed before signs of brain stem herniation, as a mean of improving mortality and patient outcome (Hacke *et al.* 1996; Kilincer *et al.* 2005; Schwab *et al.,* 1998; Mori *et al.,* 2004; Zuccarello *et al.,* 1999; Lam *et al.,* 2005). According to Schwab *et al.,* 1998 early hemicraniectomy also reduces the time of critical care therapy from 13.3 to 7.4 days. Although no statistical significance was reached, we observed an important trend toward poor prognosis in the group of patients that had pupillary changes. Batjer *et al*., 1990 demonstrated that early decompression in massive ICH limited hospital stay to 28 +/- 2days. Juvela *et al.,* 1989 studied the stay in hospital was limited to less than a month in patients who opted for decompressive craniectomy. Zucarello *et al*., 1999 showed that early intervention in ICH reduced ICU stay to less than 2 weeks. Our study with early intervention within the first 24 hour showed hospital stay of 24±5 days.

Radiographic signs such as early hypodensity of >50% of the MCA territory and/or additional vascular territories (ACA or PCA) (Mori *et al.,* 2004; Lam *et al.,* 2005; Krieger *et al.,* 1999; Juvela *et al.,* 1989), ICA infarct (Kilincer *et al.,* 2005), midline shift ≥10 mm (Kilincer *et al.,* 2005; Lam *et al.,* 2005; Auer *et al.,* 1989), effacement of subarachnoid space,attenuation of corticomedullary differentiation (Lam *et al.,* 2005; David Mendelow *et al.,* 2013), presence of hydrocephalus are predictive towards developing malignant edema or bad outcome (Lam *et al.,* 2005; Barber *et al.,* 2003; David Mendelow *et al.,* 2013) Infarct volume of more than 200 cm^3 has 91% accuracy to predict malignant hemispheric infarction (Mori *et al.,* 2004) and the extent of infarct of more than two-thirds of MCA territory has a sensitivity of 93% and specificity of 95% and they are the two most sensitive and specific single explanatory variable for prediction of mortality (Lam *et al*., 2005). On the other hand, brain edema is maximized after 24-72 hours (Lam *et al*., 2005; Auer *et al.,* 1989), so an early CT examination should not be considered sensitive enough to predict the final outcome (Lam *et al.,* 2005; Zuccarello *et al.,* 1999). Clinical signs such as early clinical deterioration (Kilincer *et al.,* 2005), early nausea or vomiting (Krieger *et al.,* 1999), and a (NIHSS) score ≥20 for left or ≥15 (Krieger *et al.,* 1999; Barber *et al.,* 2003) for right hemisphere infarction (Krieger *et al.,* 1999), pre-operative GCS score≤7 (Kilincer *et al.,* 2005), hypertension or heart failure, and increased peripheral white blood cell count (Mori *et al.,* 2004; Krieger *et al.,* 1999), also may predict which patients will develop malignant edema or have a poor outcome. Lam *et al*., 2005 indicate that a NIHSS >22 is predictive of high mortality. In our study with reference to previous studies we took up patients within 24 hrs of presentation and it showed a favorable outcome. STICH1(Mendelow *et al.,* 2005; Haemorrhage, 2005) trials used patients mainly with signs of herniation which did not give favorable outcome for the trial. Our mean NIHSS Score was ≥ 30 despite which the outcome was favorable, this is probably due to early surgical intervention.

Time from stroke to surgery has also been studied before. Non-randomized series have suggested that outcome is substantially improved if surgical treatment is initiated within 24 h of stroke onset as compared with longer time windows for treatment (Vahedi *et al.,* 2007; Schwab *et al.,* 1998; Woertgen *et al.,* 2004; Mendelow *et al.,* 2004). Schwab *et al.,* 1998 presented benefits of decompression before 24 hours after stroke. In a group of 31 patients, 26 (84%) had a BI >60 at follow up in their study. Gupta *et al.,* 2004 however, did not show benefit to surgery<24 hours, probably due to a greater proportion of patients (64%) with signs of herniation before surgery in his group. Vahedi *et al.,* 2007 in a systematic review, conclude that the timing of surgery did not affect outcome. Batjer *et al*., 1990 was able to demonstrate the need and response of early surgery <24hrs with some positive response in patients with signs of herniation. Zucarello *et al.,* 1999 showed in his study that depending upon the bleed volume patient may be taken up for surgery even with signs of herniation.

In our study the post op status patients were taken up for early tracheostomy for better toileting and reduction of anatomical dead space. This showed lesser incidence of aspiration pneumonia and better improvement of general condition of patient as the lungs clear and cerebral circulation improve. This was evident from the fact that 6 patients from our cohort who did well post decompression, where tracheostomy was deffered, died due to aspiration. Early tracheostomy also limited the ICU stay to a mean of 14±4 days. The age has been demonstrated to be an important predictor of outcome in decompressive hemicraniectomy. There are reports of poor functional outcomes and increased mortality in older patients compared to younger (Holtkamp *et al.,* 2001; David Mendelow *et al.,* 2013; Carter *et al.,* 1997). The cut-off point age to predict a good outcome is uncertain. Wijdicks and Diringer, 1998 studied the natural history of 42 patients with MCA territory infarction, 3 of 11 patients (28%) <45 years died, whereas 20 of 22 patients >45 years, 90.9% died. Important studies suggest that the optimal recovery occurs in patients less than 50 years (Gupta *et al.,* 2004; Carter *et al.,* 1997). However, Holtkamp *et al.,* 2001 used a cut-off point of 55 years and Kilincer *et al.,* 2005 when selected 60 years as a cut-off point, provided one of the strongest predictors of outcome. In our series, there was no statistical difference. Ourmean age 50 ±12 with males >females was not found to be a determinant factor.

Offering life-saving treatment for large dominant hemisphere cerebrovascular accidents is controversial, mainly because surgery may leave patients with an unacceptable poor quality of life because of hemiplegia and aphasia[28].The side of the infarct did not have prognostic relevance in our study, as demonstrated by other series (Gupta *et al.,* 2004; Kilincer *et al.,* 2005; Mori *et al.,* 2004). In Gupta *et al.,* 2004 review, the 27 patients who had decompression of the dominant hemisphere had functional outcome similar to the 111 patients who had non-dominant infarcts. In Kilincer *et al.,* 2004, half of the patients had dominant hemispheric infarction with global aphasia preoperatively, 6/7 patients in the good outcome group had a dominant hemispheric infarction and most of the patients showed considerable improvements in their aphasia, a finding confirmed by other authors (Rieke *et al.,* 2005; Schwab *et al.,* 1998; Kastrau *et al.,* 2005). Juvela *et al.,* 1989 study showed half of the patients with dominant hemisphere haemorrhage but the outcome was not significantly correlating (Juvela *et al.,* 1989).This study with 19 dominant lobe infarcts and 21 dominant lobe haemorrhagic stroke who underwent surgery did not show any improvement in the aphasia at discharge.

In conclusion, decompressive craniectomy for space-occupying large hemispheric cerebrovascular events increases the probability of survival that can yield good functional outcomes in most cases. Careful patient selection, made on an individual basis, and early operation may improve the functional outcome for large hemispheric events. Information about quality of life of survivors is essential for guiding such decisions because most patients require extensive rehabilitative therapy and lifelong assistance. There are limitations in our study. Although we present important data about decompressive surgery, it is a non-randomized retrospective study. Although there is no consensus guidelines for surgical treatment of massive hemispheric events, we conclude that:

- in patients under 60 years old
- in patients with CT scan evidence of massive cerebrovascular accidents with GCS $\geq$8
- decompressive craniectomy within first 24 hours or signs of brain herniation whichever comes first.
- Dominant hemispheric infarction does not represent an exclusion criteria.
- Early tracheostomy by 10th day.
- Neurologist must take up an aggressive approach to ensure that decompressive craniectomy is done

From the data evaluated we believe that this procedure should be offered for all patients with massive CVA's and that randomization of patients to medical management would be unethical as benefit overwhelms in patients who underwent decompression.

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