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Comparative Study on Decompressive Craniectomy with Clot Evacuation Versus Medical Management in Hypertensive Intracerebral Hemorrhage: An Institutional Cohort Study

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Abstract: ***<u>Introduction</u>: Intracerebral hemorrhage (ICH) is a critical form of stroke, especially prevalent in specific demographics, resulting in significant morbidity and mortality. Decompressive craniectomy with hematoma evacuation is proposed to alleviate intracranial pressure, but its efficacy relative to conservative management remains controversial. Ongoing research investigates minimally invasive interventions, yet clinical guidelines vary, and long - term prognostic data is insufficient. This study aims to evaluate outcomes associated with neurosurgical versus medical management in hypertensive ICH cases. <u>Methods</u>: This retrospective cohort study at Kanyakumari Government Medical College and Hospital analyzed 105 adult patients with hypertensive intracerebral hemorrhage (ICH) from July 2022 to June 2024. Participants were divided into surgical and medical management groups, with outcomes assessed for mortality and functional outcome. Data were analyzed to identify predictive factors for surgery and mortality, considering a significance level of p < 0.05. Limitations included potential selection bias and single - centre design. The study aims to improve understanding of treatment efficacy for hypertensive ICH. <u>Results</u>: The study involved 105 surgical patients with intracerebral hemorrhage (ICH), of whom 50 underwent decompressive craniectomy. Most ICH cases were in the gangliocapsular and lobar regions, with similar male - to - female ratios and no significant differences in risk factors. Predictive factors for surgery included age, ICH volume, and midline shift, while mortality was linked to ICH volume and prior ICH history. <u>Discussion</u>: The study found no significant improvement in surgical outcomes for spontaneous supracentimetric intracerebral hemorrhage (ICH) compared to conservative management, aligning with STICH II results. Despite a minor reduction in mortality, factors like limited healthcare access in India impacted outcomes. Many patients were admitted to non - specialized neurosurgery departments instead of dedicated stroke units, essential for optimal care. While surgery was linked to longer survival, it also resulted in higher complication rates and prolonged hospital stays. <u>Conclusion</u>: Our study found no overall benefit of surgery for spontaneous supracentimetric ICH compared to conservative care. Surgical patients were generally younger and had more severe conditions. Further research is needed to refine patient selection and standardize procedures in stroke centres.***

Keywords: Intracerebral hemorrhage, Decompressive craniectomy and clot evacuation, Supracentimetric ICH

1. Introduction

The American Stroke Association defines intracerebral hemorrhage (ICH) as "the rapid development of neurological signs and symptoms attributable to the accumulation of blood within the brain parenchyma or ventricles not caused by trauma".1 10%–27% of strokes worldwide are caused by intracerebral hemorrhage (ICH), which is more common in Asian and African American populations.1 In India, stroke ranks as the second most common cause of death and disability. [1] Hypertensive intracerebral hemorrhage (ICH) is associated with high morbidity and mortality rates, despite advancements in medical management. Approximately 40% of people die from it within a 30 days interval.2 The primary etiological mechanism for injury following large ICH is intracranial hypertension and resultant herniation. Patients with ICH have a poor prognosis due to structural loss of vital deep nuclei, disruption of the white matter pathway from direct hematoma - caused injury, loss of cerebral autoregulation, and delayed brain swelling.3 With a mean age of 63.8 ± 0.13 years, lower - middle - income countries have seen a significant increase in the incidence of ICH.

Decompressive craniectomy with clot evacuation has been proposed as a potential therapeutic intervention to reduce intracranial pressure and improve outcomes. However, the management strategies for patients with spontaneous supra - tentorial ICH are still controversial, and even with the development of minimally invasive procedures, the function of surgical intervention is still debatable. The Surgical Trial in Intra - cerebral Hemorrhage (STICH) [4] and other randomized controlled studies, findings imply that, for these patients, surgery does not seem to provide much of an advantage over conservative medical care.4[, 5, 6] The effectiveness of surgical intervention for ICH is still unknown. When comparing the first conservative treatment to early surgery, STICH I [5] revealed no overall benefit. Conversely, STICH II found that, at six months, early surgery did not improve the risk of mortality or disability and may have a negligible but meaningful clinical survival benefit for individuals without intraventricular bleeding who have spontaneous superficial ICH.7 In both studies, with regard to neurologic decline, a significant crossover rate was seen between the surgical group and the medical group. It's possible that these crossovers dilute any potential clinical benefits from surgical intervention. The most current meta - analysis and systematic review of 21 clinical trials with randomization, pertaining to surgery for supratentorial ICH, demonstrated that the possibility of a good functional outcome was 40% higher in patients undergoing any surgical intervention than in those who had not received it.[7, 8, 9, 10, 11, 12, 13]

Surgery for supratentorial spontaneous ICH may be beneficial, especially if minimally invasive techniques are used and the procedure is carried out soon after the onset of symptoms. The use of pioglitazone, a PPAR gamma agonist, as well as locally delivered ultrasound, thrombolytics, and recombinant tissue plasminogen activator (rtPA) are all being studied as minimally invasive surgical therapy for ICH (MISTIE, CLEAR, and SLEUTH studies).[14]

Not all stroke centers follow the same guidelines when it comes to surgical indications, thus individual cases are decided upon by the treating physician.[10, 11] However, surgical patients appear to have a higher survival rate but not a more advantageous functional result.[12] As the follow up with surgical patients tends to be less frequent, long - term data is critically inadequate in the literature.

Considering these suppositions, we carried out an observational retrospective cohort analysis at our facility, concentrating on supracentimetric spontaneous ICH that were either treated with neurosurgical therapy (Decompressive craniectomy with clot evacuation) or with conservative management. Decompressive craniectomy with clot evacuation has been proposed as a potential therapeutic intervention to reduce intracranial pressure and improve outcomes. However, the evidence supporting this surgical intervention remains controversial. This study aims to evaluate and compare the risk factors and outcomes of decompressive craniectomy with clot evacuation versus medical management in patients with hypertensive ICH.

2. Methods

Study Design and Setting: This retrospective cohort study was conducted at Kanyakumari Government Medical College and Hospital, spanning a period from July 2022 to June 2024. The institutional review board approved the study protocol, and informed consent was obtained from patients or their legal representatives where ever applicable.

Ethical Considerations: The study adhered to ethical principles outlined in the Declaration of Helsinki. Patient confidentiality was maintained throughout data collection and analysis processes.

Participants: The study included 105 consecutive adult patients diagnosed or discharged with diagnostic code of 431 ICD - 9 - CM, with supracentimetric (>1cm) hypertensive intracerebral hemorrhage (ICH) admitted to the Intensive Care Unit, Stroke Unit, Internal and Vascular Medicine, Neurosurgery, Neurology and Geriatrics departments during the study period. Diagnosis of hypertensive ICH was confirmed based on clinical presentation, neuroimaging (typically computed tomography (CT) or magnetic resonance imaging (MRI) of the brain), and exclusion of other causes such as vascular malformations or hemorrhagic transformation of ischemic stroke.

Inclusion criteria: 1. Age >50years 2. Non - traumatic intracerebral hematoma 3. Hematoma volume >30ml or size supracentimetric 4. midline shift causing mass effect 5. Without any blood dyscarasis 6. Presentation of case within 72 hrs of stroke attack or appearance of symptoms

Exclusion criteria: 1. Intracerebral hematoma caused by ruptured aneurysms, arteriovenous malformation (AVM), vascular anomaly, brain tumors, traumatic brain injury, or coagulopathy 2. ICH with IVH 3. Cerebral Venous Thrombosis 4. Hemorrhagic transformation of ischemic stroke (with or without thrombolysis) 5. Primary subdural/epidural hematoma.

Group Allocation: Patients were allocated into two groups based on the treatment they received:
- Group A (Surgical Group): Patients who underwent decompressive craniectomy with clot evacuation.
- Group B (Medical Management Group): Patients who received conservative medical management, including blood pressure control, seizure prophylaxis, and neurocritical care support.

Data Collection

Data were collected from electronic medical records regarding ICH risk factors for each patient, including age, sex, location, volume measured by the ABC/2 method[15] (to estimate ICH volume, A =maximum length in cm, B= width perpendicular to A on the same head CT slice, and C=the number of slices multiplied by the slice thickness), blood pressure, anticoagulation reversal therapy, GCS, and ICH score. History of hypertension (BP > 140/90 mmHg twice before the event or patient being currently on anti - hypertensive treatment), amyloid angiopathy (Modified Boston criteria), primary brain tumors, myocardial infarction, prior ICH or ischemic stroke, diabetes mellitus (preprandial glycaemia ≥126 mg/dL on at least 2 occasions, post - prandial glycaemia ≥ 200 mg/dL, HbA1c ≥ 6.5% or patient currently on hypoglycemic treatment), obesity (BMI ≥30 kg/m2), hyperlipidemia (total cholesterol ≥ 200 mg/dL or triglyceride ≥ 140 mg/dL or already under lipid reducing therapy), ongoing smoking, alcohol abuse (≥ 300 g per week), drugs, migraine, migraine with aura, history of symptomatic peripheral arterial disease (intermittent claudication of presumed atherosclerotic origin; or ankle/arm systolic blood pressure ratio < 0.85 in either leg at rest; or history of intermittent claudication with previous leg amputation, reconstructive surgery, or angioplasty), atrial fbrillation (AF) and/or systemic diseases (thrombocytopenia, bleeding disorders, kidney failure, liver disease). Data were collected about heparin, antiplatelet medicines, oral anticoagulants (OAT), and direct oral anticoagulants (DOAC).

The severity of ICH was measured by the ICH - score[16] at admission and surgical techniques were recorded. Data regarding intra - hospital mortality rates and duration of hospitalization was collected for each patient. Follow - ups and outcome assessment were done, not in a blinded fashion. Follow up was done when possible, in our outpatient clinic or by phone through a structure interview.[17]

Treatment Details:

- Group A (Surgical Group): Details of surgical intervention included the timing of surgery, surgical technique (e. g., size of craniectomy, method of clot evacuation), intraoperative findings, and perioperative complications.
- Group B (Medical Management Group): Information on medical treatment strategies, including medications administered, blood pressure targets, and interventions for managing complications such as hydrocephalus or secondary bleeding.

Outcome Measures: Primary outcome measures were assessed at discharge and follow - up (typically at 3 months) and included: (1) Mortality Rates: Defined as death occurring during hospitalization or within the follow up period. (2) Functional Outcomes: Assessed using the modified Rankin Scale (mRS), a validated tool for measuring functional disability and dependency in activities of daily living. Secondary outcome measures included: (1) Complications: Such as surgical site infections, hemorrhagic transformation, cerebral edema, and medical complications (e. g., pneumonia, urinary tract infections). (2) Length of Hospital Stay: Defined as the duration from admission to discharge or transfer to rehabilitation facilities.

Statistical Analysis: Statistical analysis was performed using appropriate methods based on the distribution of data. Continuous variables were presented as mean ± standard deviation or median (interquartile range), and categorical variables as frequencies and percentages. Between - group comparisons were conducted using independent t - tests, Mann - Whitney U tests, or Chi - square tests as appropriate. A p - value < 0.05 was considered statistically significant.

Limitations: Limitations of this study include its retrospective design, potential selection bias, and the single - center nature which may limit generalizability. Additionally, variations in individual patient management decisions could influence outcomes, despite attempts to standardize treatment protocols within the institution.

Variations in the characteristics of ICH classified in surgical or medical management and the characteristics of deceased and non - deceased patients were tested using the chi - Square test for categorical variables. A p value < 0.05 were considered significant. Various logistic regression models (multivariate analyses) were used as a second step to verify the predictive factors associated with the neurosurgical intervention and mortality. The following variables were of interest: A) for the first model (predictive factors associated with surgery), in addition to clinical characteristics of patients (age, sex, and severity), variables that were included are the characteristics of the ICH (anterior versus posterior, lobar or deep seated, lesion size, midline shift, presence of edema, hydrocephalus, intraventricular extension) and the ICH score. B) in the second model (predictive factors associated with mortality) the clinical characteristics of the patients (like sex, age, diabetes, AF, previous ICH, MI or stroke), the characteristics of the hemorrhage, the ICH score, and surgery were included. The Odds Ratio (OR) with 95% confidence intervals were used for the analysed results.

3. Results

A total of 126 surgical patients were identified based on the 431 ICD - 9 code, 21 patients were excluded because they had traumatic ICH, AVM or aneurysm. A total of 105 patients were included in the study, and 50 patients underwent decompressive craniectomy with clot evacuation.

Table 1: ICH location and main presentations at onset

Location	Total	Surgical	Conservative	*p* - value
Right	57 (54%)	27 (54%)	30 (55%)	0.22
Left	46 (44%)	22 (44%)	24 (44%)	0.2
Central	2 (2%)	1 (2%)	1 (2%)	0.88
Lobar	49 (47%)	24 (48%)	25 (45%)	0.64
Deep (GC)	42 (40%)	17 (34%)	25 (45%)	0.1
Cerebellar	12 (11%)	8 (16%)	4 (7%)	0.07
Brainstem	2 (2%)	1 (2%)	1 (2%)	0.67
Supratentorial	91 (87%)	41 (82%)	50 (90%)	0.13
Infratentorial	14 (13%)	9 (18%)	5 (9%)	0.13
Presentation at onset	Total	Surgical	Conservative	*p* - value
Seizures	37 (35)	18 (36)	19 (35)	
Hydrocephalus	12 (12%)	9 (18%)	3 (6%)	0.035
Herniation	13 (12%)	8 (16%)	5 (9%)	0.2
Mean volume (cc)	53.37	57 ± 25.2	44 ± 56.2	0.3
Mean ICH score	2.3	3	1.9	0.04
ICH score 0	8 (8%)	1 (2%)	7 (13%)	0.0003
ICH score 1	12 (11%)	3 (6%)	9 (16%)	0.0018
ICH score 2	12 (11%)	9 (18%)	3 (6%)	0.005
ICH score 3	20 (19%)	16 (32%)	4 (7%)	0.05
ICH score 4	33 (32%)	18 (36%)	15 (27%)	0.93
ICH score 5	13 (12%)	2 (4%)	11 (20%)	0.46
ICH score 6	7 (7%)	1 (2%)	6 (11%)	0.88
Midline shift (mm)	5.38 ± 5.99	7.83 ± 5.52	4.01 ± 5.78	0.001
Mean systolic BP (mmHg)	159 ± 33	177 ± 39	152 ± 32	0.019
Mean diastolic BP (mmHg)	87 ± 19	95 ± 22	89 ± 19	0.099
mRS	1.4	0.8	1.9	0.04
Reversal therapy	13 (13%)	6 (12%)	7 (13%)	0.69

Concerning the ICH locations, most recorded cases were those in the gangliocapsular region and lobar and a smaller number was found to be located in the brainstem. (Table 1).

Table 2: Characteristics and risk factors

Characteristics	Total	Surgical	Conservative	*p* - value
	105	50	55	
Male	71 (67.6%)	31 (62%)	38 (69%)	0.90
Female	34 (32.4%)	19 (38%)	17 (31%)	0.91
Mean age (y)	68.3 ± 16.4	66.5 ± 15.9	74.5 ± 14.1	0.003
Risk Factors	Total	Surgical	Conservative	*p* - value
Anticoagulant	25 (23.8%)	10 (20%)	15 (27.2%)	0.80
Antiplatelet	29 (27.6%)	13 (27%)	16 (28%)	0.73
Hypertension	82 (78%)	36 (71%)	46 (83.6%)	0.59
Amyloid angiopathy	4 (3.8%)	1 (2%)	3 (5%)	0.36
Alcohol	23 (21.9%)	15 (30%)	8 (14.5%)	0.70
Venous thrombosis	1 (1%)	0	1 (1.8%)	
Diabetes	51 (48.6%)	28 (56%)	23 (41.8%)	0.20
Previous MI	12 (11.4%)	5 (10%)	7 (12.7%)	0.66
AF	30 (28.6%)	14 (28%)	16 (29%)	0.13
Previous stroke	22 (20.9%)	6 (12%)	16 (29%)	0.17
Previous ICH	16 (15.2%)	8 (16%)	8 (14.5%)	0.72
Cognitive impairment	31 (29.5%)	10 (20%)	21 (38%)	0.07
Covid	8 (7.6%)	0	1 (2%)	
Liver disease	9 (8.5%)	4 (8%)	5 (9%)	0.15
Obesity	11 (10.4%)	4 (8%)	7 (12.7%)	0.61
Smoke	42 (40%)	20 (40%)	22 (40%)	0.75
Chronic Kidney Disease	10 (9.5%)	4 (8%)	6 (10.9%)	0.54
Tumors	7 (6.6%)	4 (8%)	3 (5.4%)	0.41
Hematological tumors	1 (1%)	1 (2%)	0	
Antithrombotic Therapy	Total	Surgical	conservative	*p* - value
Antiplatelet	28 (26%)	7 (14%)	21 (38%)	0.62
VKA	7 (7%)	2 (4%)	5 (9%)	0.51
Heparin products	2 (2%)	1 (2%)	1 (2%)	0.90
DOAC	12 (11%)	4 (8%)	8 (15%)	0.58
Association	2 (2%)	0	2 (4%)	

The male and female ratio were almost the same in both groups, the surgical group were younger, but no statistically significant difference were noted among the two groups when it comes to risk factors and antithrombotic therapy. (Table 2).

Table 3: Hospitalization departments, non - neurological complications and outcomes

	Total	Surgical	Conservative	*p* - value
Intensive Care Unit	43 (41%)	31 (62%)	12 (22%)	< 0.0001
Stroke unit	35 (33%)	5 (14%)	30 (55%)	0.032
Other	27 (26%)	2 (4%)	25 (45%)	0.004
Mean Hospital stay (days)	18 ± 16	27 ± 14	14 ± 11	< 0.00001
Infectious complications	61 (58%)	42 (84%)	19 (35%)	0.003
Thrombotic complications	30 (28%)	22 (44%)	8 (15%)	< 0.00001
Mechanical ventilation	66 (63%)	41 (82%)	25 (45%)	< 0.00001
Tracheostomy	35 (33%)	34 (68%)	1 (2%)	<0.0001
PEG	6 (6%)	5 (10%)	1 (2%)	0.3
Seizures	22 (21%)	12 (24%)	10 (18%)	0.44
Outcomes	Total	Surgical	Conservative	*p* - value
In - hospital death	37 (35%)	29 (58%)	8 (15%)	0.83
3 months - survival	54 (51%)	17 (34%)	37 (67%)	0.81
6 months - survival	42 (40%)	12 (24%)	30 (55%)	0.79
Dead at follow - up	37 (35%)	8 (16%)	25 (46%)	0.28
Survival mean (months)	3.5	6.3	2.25	< 0.00001

In the intensive care unit and stroke unit, there was a statistically significant difference between the number of patients treated conservatively and those who had decompressive craniectomy and clot evacuation; the former group was significantly larger. Conservatively treated patients were equally likely to have been admitted to the neurosurgery department and the stroke unit or other departments, but the neurosurgery department's hospital stays were longer due to the patients' frequent infections. There is a minor difference between the two groups in terms of survival. (Table 3) However, post operative haemorrhage contributed a significant portion of post operative complications in a few patients in the surgical group

Functional Outcomes measured using Modified Rankin Scale (mRS) showed a relatively good functional outcome (score 0

- 3) in the group of patient who underwent decompressive craniectomy with clot evacuation (55%) in comparison to those who were managed conservatively (45%). Odds ratio (OR) for good functional outcome (mRS 0 - 3) favored the surgical group significantly (OR = 2.14, 95% CI 1.03 - 4.45, p = 0.038).

In the first model, the predictive factors associated with those who underwent decompressive craniectomy and clot evacuation were the age (*p* - value < 0.0001), the volume at the onset (*p* - value 0.04), the midline shift seen with neuroimaging (*p* - value 0.02), the ICH score (*p* - value o.004) and the systolic BP on presentation at the Emergency department (*p* - value 0.0001).

In the second model, the predictive factors associated with mortality at six months were volume (*p* - value 0.02) and history of previous ICH (*p* - value 0.03).

4. Discussion

Comparing our patient group with spontaneous supracentimetric ICH to conservative care, there was no statistically significant improvement in the surgical outcome. The findings are consistent with those of STICH II, which found that, six months later, early surgery did not raise the risk of death or disability. Our study had a high death rate of 35%, which was consistent with prior studies that found high rates of in - hospital and 1 - year mortality (32.4% and 45.4%, respectively) [18, 19]. In contrast to the notable improvement in the prognosis for ischemic stroke during the previous ten years, the authors of the publications observed a small improvement in the death rate from ICH. Furthermore, in our study, in - hospital and 1 - year mortality rates dropped by 2.5% (from 37.5% to 35% %, P < 0.28) and 1.2% (from 50.0% to 48.8%, P < 0.34), respectively, which was not statistically significant. This minor improvement was likely brought on by slight improved acute hospital care, which in turn led to a decrease in mortality.[18, 19] In developing countries like India, where there is a shortage of healthcare and transportation facilities and where affordability of medical care is a big question for the common people, patients typically are unaware of the various medical conditions and present late for neurocritical and neurointensive care. Compared to various published data, we did not observe any significant decrease in intrahospital mortality.[20] The aforementioned risk variables for ICH, such as age and high NIHSS upon admission, were also strongly related with intra - hospital mortality, which is consistent with various other published data.[21]

A quarter of patients i. e 25%, treated conservatively were admitted to the neurosurgery department, which is not specialized in stroke patients, and unfortunately only 33% of ICH patients were admitted to the stroke unit. Stroke units provide specialized, multidisciplinary care, close monitoring, and therapies that are specifically designed to meet the needs of stroke patients, including those with ICH. This multidisciplinary approach of care has been shown to be very useful for individuals with ICH. Care in a stroke unit dramatically increases survival and lowers the likelihood of impairment in stroke patients, including those with ICH, according to numerous studies. In presence of stroke specialists, problems like elevated intracranial pressure or neurological decline can be promptly and appropriately managed. Early rehabilitation by logopedics and physiotherapists also speeds up recovery and enhances patients' short - and long - term functional outcomes.[22] As a result, 65% of our patients did not receive the best care possible.[23]

In terms of hospitalization, the neurosurgical group saw a statistically significant increased incidence of complications (mostly thrombosis and infections) and a longer mean hospital stay (27 ± 14 days compared to 14 ± 11 days). India has one of the highest infection rates in the Asian countries, according to the European Center for Infectious Diseases (ECDC); roughly 7 - 20% of hospitalized patients get hospital - acquired infections. The risk of counteracting the advantages of surgical operations may be increased by the higher infection rate observed in Indian structures.

Younger patients, patients presenting with a midline shift, patients with a higher ICH volume, and patients with a higher ICH score at admission were all candidates for surgical treatment. Even in cases where there is no chance of survival, there is a general propensity to overtreat younger patients.

The patients who underwent surgery had a longer mean survival time at the follow - up. However, the surgical group's lengthier hospital stay resulted in a higher rate of thrombotic and infectious problems, as well as the requirement for invasive procedures like tracheostomy and PEG. Aslo, the surgical group tend to show an improved functional outcome as compared to the conservative group which was statistically significant.

The deep brain nucleus affected determines the optimal hematoma volume cutoffs for predicting a poor outcome in deep ICH, [24] and older patients are more likely to go untreated, which results in additional injury later on. But following the acute phase, when patients recover from main and secondary damage, ICH are said to have a higher chance of recovery than ischemic stroke.[25]

5. Conclusion

When compared to conservative care, the patient in our study with spontaneous supracentimetric ICH did not demonstrate any overall benefit from surgery. We must take into consideration, too, that surgical patients were often younger, had more severe clinical symptoms, a greater ICH volume, and a more noticeable midline shift. More evidence is required for a more focused patient selection process that aims to standardize surgical procedures, and these patients must be treated in a stroke center specifically designed for that purpose.

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