



CRANIOTOMY VERSUS CONSERVATIVE MANAGEMENT IN INTRACEREBRAL HEMORRHAGE: COMPARISON OF OUTCOMES AND COMPLICATIONS

Neurosurgery

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ABSTRACT

Background: The choice between craniotomy and conservative management in intracerebral hemorrhage (ICH) remains debated. **Methods:** In this prospective comparative study in Bhopal, India, 68 adults with CT-confirmed spontaneous ICH were followed for three months. Fifty-one underwent craniotomy with hematoma evacuation and 17 were managed conservatively, as decided by the treating team. Outcomes were the Glasgow Outcome Scale (GOS), modified Rankin Scale (mRS), mortality, length of stay and complications. **Results:** Mean age was 56.6 years; 75.0% were hypertensive. All 28 patients with a severe Glasgow Coma Scale (GCS) score were operated. A good GOS outcome occurred in 86.3% of the craniotomy group and 29.4% of the conservative group ($p < 0.001$). Mortality was 13.7% versus 35.3% ($p = 0.074$). ICU and hospital stay were similar. Pneumonia was more frequent after craniotomy (58.8% vs 47.1%) and rebleeding with conservative care (64.7% vs 37.3%). Treatment modality was the only significant predictor in regression ($p = 0.001$), but the estimate was imprecise (95% CI 3.6–100.1). **Conclusion:** Craniotomy was associated with better functional outcome, but treatment was allocated by severity and the model omitted GCS, so this is not a proven treatment effect. Larger multicentre studies adjusting for baseline severity are needed.

KEYWORDS

Intracerebral Hemorrhage; Craniotomy; Conservative Management; Glasgow Outcome Scale; Modified Rankin Scale

1. INTRODUCTION

Intracerebral hemorrhage (ICH) is bleeding directly into the brain parenchyma. It is a devastating cerebrovascular event with high mortality and morbidity. A pooled global incidence of 29.9 per 100,000 person-years has been reported, rising steeply after 65 years [1]. Thirty-day mortality is about 35–40%, and only a minority of survivors regain functional independence [1]. In Asian populations ICH accounts for 17–33% of all strokes, roughly twice the proportion in Western countries [2]. Hospital-based Indian series report hypertension in 58–70% of patients [3,4].

The best way to manage ICH has been debated for decades, in particular whether to evacuate the hematoma early by craniotomy or to treat conservatively. Conservative management rests on blood pressure control, reversal of coagulopathy, intracranial pressure management, seizure prophylaxis when indicated and neurocritical care. Craniotomy removes the hematoma and relieves mass effect, but it may add parenchymal injury, infection and rebleeding. The 2022 American Heart Association/American Stroke Association guideline regards the usefulness of craniotomy for supratentorial ICH as uncertain (Class 2b). It accepts craniotomy as a life-saving measure in patients who deteriorate because of mass effect [5].

Randomised evidence has not settled the question. The STICH trial (1,033 patients) found no overall benefit from early surgery [6]. STICH II was restricted to superficial lobar hematomas of 10–100 mL without intraventricular extension and also found no significant improvement in its primary outcome [7]. Minimally invasive techniques are now being tested as an alternative [8]. Comparative data from Indian tertiary centres are limited and inconsistent. We therefore compared the outcomes and complications of craniotomy and conservative management in patients with ICH at a tertiary care centre in central India.

2. Literature Survey

Indian comparative studies point in different directions. In a randomised study of 61 patients with supratentorial ICH (GCS 4–14, hematoma >30 mL), mortality was lower with surgery than with medical management (61.8% vs 85.2%, $p = 0.043$), but dependency at three months did not differ [9]. In 119 patients younger than 70 years with hematomas >30 mL, 90-day mortality was 31.9% with surgery and 57.4% with medical management ($p = 0.006$), yet median mRS scores were almost identical [10]. A single-centre study of 661 patients with spontaneous ICH found lower median mRS scores in the conservatively managed group, but the difference disappeared after adjustment for the ICH score [11]. Among 132 patients who had hematoma evacuation, decompressive craniectomy and standard craniotomy showed similar mortality (26.5% overall) and functional outcome after propensity matching [12].

Elsewhere, a propensity-matched study of minor basal ganglia hemorrhage reported a favourable 12-month outcome in 81% of conservatively treated patients against 44% of surgical patients, with more pneumonia after surgery [13]. Complications after open craniotomy are well recognised. In a small series of 27 patients, deaths were attributed to pneumothorax, respiratory infection, cerebral oedema and rebleeding [14]. In a validation study of 617 Indian patients, 30-day mortality was 28.5% [15]. Together, these reports show that the apparent effect of surgery depends on hematoma size, location and baseline severity, and on how these are adjusted for.

3. Problem Definition

Aim. To compare the outcomes and complications of craniotomy and conservative management in patients with intracerebral hemorrhage.

Objectives. (1) To compare mortality between the two treatment groups. (2) To compare functional outcome, measured by the Glasgow Outcome Scale (GOS) and the modified Rankin Scale (mRS). (3) To compare complications (infection, pneumonia and rebleeding) and neurological deficits. (4) To identify factors associated with the choice of treatment. (5) To identify independent predictors of outcome.

4. Methodology

4.1 Study Design and Setting

This was a prospective comparative observational study conducted over 18 months in the Department of General Surgery, L.N. Medical College and JK Hospital, Bhopal, Madhya Pradesh, India. The hospital is a tertiary care centre with advanced neuroimaging and neurosurgical facilities. Diagnosis, treatment decisions and monitoring were all carried out within the same institution. The study started after approval by the Institutional Ethics Committee.

4.2 Participants

Patients presenting to the outpatient department, emergency services or inpatient wards with features suggestive of ICH were screened. The inclusion criteria were: age ≥ 18 years; spontaneous ICH confirmed on CT of the brain; presentation within 72 hours of symptom onset; management by craniotomy or conservative treatment; and willingness to participate with informed consent. The exclusion criteria were subarachnoid hemorrhage, hemorrhage secondary to tumours or vascular malformations, incomplete clinical or radiological data, and loss to follow-up.

4.3 Sample Size and Treatment Groups

The sample size ($n = 68$) was determined by the number of eligible patients during the study period. No formal power calculation was performed. Patients were grouped by the treatment they received: Group A, craniotomy with hematoma evacuation; Group B, conservative medical management. The treating neurosurgeon or

physician chose the treatment from the clinical condition, CT findings and institutional protocol, independently of the study. In both groups, patients received supportive care that included blood pressure control, intracranial pressure management, seizure prophylaxis and intensive care support when required.

4.4 Clinical and Radiological Assessment

A structured proforma recorded age, sex, presenting symptoms, hypertension, diabetes mellitus and the Glasgow Coma Scale (GCS) score at admission. GCS was categorised as severe, moderate or mild (3–8, 9–12 and 13–15 respectively). All patients had a non-contrast CT of the brain at admission. Hematoma volume was estimated with the ABC/2 method and intraventricular extension was recorded. ICU admission, ventilatory support and duration of hospital stay were documented. Data were kept in a secure database and patient confidentiality was maintained.

4.5 Outcomes and Follow-up

The primary outcomes were mortality and functional outcome. Functional outcome was graded with the GOS at discharge and with the mRS at three months. The GOS was dichotomised into good outcome (good recovery or moderate disability) and poor outcome (severe disability, persistent vegetative state or death). An mRS of 0–3 was regarded as favourable and 4–6 as unfavourable. Secondary outcomes were ICU stay, hospital stay, neurological deficits and complications (rebleeding, infection and pneumonia). Patients were followed for three months by outpatient visit or telephone contact.

4.6 Statistical Analysis

Data were entered in Microsoft Excel and analysed with the Statistical Package for the Social Sciences (SPSS). Continuous variables are given as mean ± standard deviation and categorical variables as number (percentage). Categorical variables were compared with the chi-square test, or with Fisher's exact test (Fisher–Freeman–Halton test for tables larger than 2 × 2) when any expected cell count was below 5. Continuous variables were compared with the independent-samples t-test. Multivariable binary logistic regression was used to identify independent predictors of GOS outcome (good vs poor), with treatment modality, age category, sex, hypertension, diabetes mellitus and hematoma volume category (<30 mL vs >30 mL) as covariates. A p-value below 0.05 was taken as statistically significant.

4.7 Ethical Considerations

Written informed consent was obtained from all patients or their legally authorised representatives. Participation was voluntary, patients could withdraw at any stage without effect on their treatment, and no test or procedure beyond routine care was performed for the study.

5. RESULTS AND DISCUSSION

5.1 Study Population

Sixty-eight patients were analysed. Fifty-one (75.0%) underwent craniotomy and 17 (25.0%) were managed conservatively. Mean age was 56.62 ± 11.62 years (median 56), and the largest age group (26 patients, 38.2%) was older than 60 years. There were 41 women (60.3%) and 27 men (39.7%). Hypertension was present in 51 patients (75.0%) and diabetes mellitus in 30 (44.1%). Mean admission GCS was 9.56 ± 3.38 (median 10): 28 patients (41.2%) had a severe, 22 (32.4%) a moderate and 18 (26.5%) a mild score. Mean hematoma volume was 37.19 ± 21.91 mL, and 33 patients (48.5%) had a volume >30 mL. Intraventricular extension was present in 27 patients (39.7%), and 20 (29.4%) needed ventilatory support. Mean ICU stay was 8.34 ± 3.73 days and mean hospital stay 14.87 ± 5.88 days.

5.2 Baseline Comparison of the Treatment Groups

Age distribution, sex and diabetes were similar in the two groups (Table 1). Hypertension was more frequent in the craniotomy group (82.4% vs 52.9%, p = 0.024). Admission GCS differed sharply. All 28 patients with a severe GCS were operated, and no conservatively managed patient had a severe score (p < 0.001; Figure 1a). Severity at presentation therefore strongly determined the choice of treatment.

Table 1. Baseline Characteristics by Treatment Group, n (%)

Characteristic	Overall (N=68)	Craniotomy (n=51)	Conservative (n=17)	p-value
Age group, years				0.54
30–40	4 (5.9)	3 (5.9)	1 (5.9)	
41–50	20 (29.4)	16 (31.4)	4 (23.5)	

51–60	18 (26.5)	15 (29.4)	3 (17.6)	
>60	26 (38.2)	17 (33.3)	9 (52.9)	
Sex				0.67
Male	27 (39.7)	21 (41.2)	6 (35.3)	
Female	41 (60.3)	30 (58.8)	11 (64.7)	
Hypertension	51 (75.0)	42 (82.4)	9 (52.9)	0.024
Diabetes mellitus	30 (44.1)	24 (47.1)	6 (35.3)	0.40
Admission GCS Category				<0.001
Severe	28 (41.2)	28 (54.9)	0 (0.0)	
Moderate	22 (32.4)	12 (23.5)	10 (58.8)	
Mild	18 (26.5)	11 (21.6)	7 (41.2)	

GCS, Glasgow Coma Scale. p-values: chi-square test (sex, diabetes mellitus); Fisher's exact test (hypertension); Fisher–Freeman–Halton exact test (age group, GCS category). Group comparisons were calculated from the reported counts.

5.3 Mortality, Functional Outcome and Length of Stay

At discharge, GOS was death in 7 patients (10.3%), persistent vegetative state in 6 (8.8%), severe disability in 6 (8.8%), moderate disability in 30 (44.1%) and good recovery in 19 (27.9%). Overall mortality at three months was 13 of 68 (19.1%). A good GOS outcome occurred in 86.3% of the craniotomy group and 29.4% of the conservative group (p < 0.001; Table 2). The mRS distribution also differed (p < 0.001; Figure 1b): no conservatively managed patient was free of symptoms, against 18 patients (35.3%) after craniotomy. Mortality was 13.7% (7/51) after craniotomy and 35.3% (6/17) with conservative management. This difference was not statistically significant on Fisher's exact test (p = 0.074). ICU stay and hospital stay did not differ between groups. A neurological deficit was recorded in 19 patients (27.9%); motor deficit, sensory deficit and abnormal reflexes were recorded in 32 (47.1%), 34 (50.0%) and 34 (50.0%) patients.

Table 2. Functional Outcome, Mortality and Length of Stay by Treatment Group, n (%)

Outcome	Craniotomy (n=51)	Conservative (n=17)	p-value
GOS (dichotomised)			<0.001
Good outcome (good recovery or moderate disability)	44 (86.3)	5 (29.4)	
Poor outcome (severe disability, vegetative state or death)	7 (13.7)	12 (70.6)	
Modified Rankin Scale, 3 months			<0.001
No symptoms	18 (35.3)	0 (0.0)	
Slight disability	25 (49.0)	5 (29.4)	
Moderate disability	1 (2.0)	6 (35.3)	
Death	7 (13.7)	6 (35.3)	
Mortality, 3 months	7 (13.7)	6 (35.3)	0.074
ICU stay, days (mean ± SD)	8.63 ± 3.76	7.47 ± 3.59	0.27
Hospital stay, days (mean ± SD)	15.02 ± 6.13	14.41 ± 5.21	0.71

GOS, Glasgow Outcome Scale. p-values: Fisher's exact test (GOS, mortality); Fisher–Freeman–Halton exact test (mRS); independent-samples t-test (ICU and hospital stay), calculated from the reported group means, standard deviations and sample sizes. These recalculated t-test p-values differ from the values given in the source thesis (0.657 for ICU stay and 0.180 for hospital stay); the discrepancy could not be resolved without access to patient-level data, and the independently verifiable calculation from the reported summary statistics is presented here.

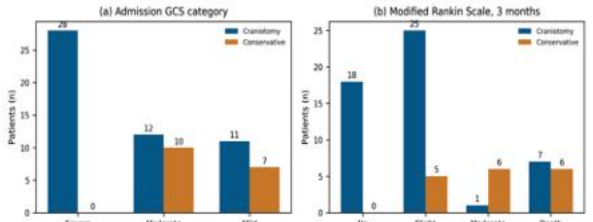


Figure 1. (a) Admission GCS Category and (b) Modified Rankin Scale at three Months, by Treatment Group. Numbers Inside Bars are Patient Counts. No Conservatively Managed Patient had a Severe GCS Score, and None was Free of Symptoms on the mRS.

5.4 Complications

Complications were common (Table 3). Pneumonia occurred in 38 patients (55.9%), infection in 34 (50.0%) and rebleeding in 30 (44.1%). Pneumonia was more frequent after craniotomy (58.8% vs 47.1%, $p = 0.40$). Infection was similar (49.0% vs 52.9%, $p = 0.78$). Rebleeding was more frequent with conservative management (64.7% vs 37.3%); the chi-square p -value was 0.048, but Fisher's exact test gave $p = 0.089$.

Table 3. Complications by Treatment Group, n (%)

Complication	Overall (N=68)	Craniotomy (n=51)	Conservative (n=17)	p-value
Infection	34 (50.0)	25 (49.0)	9 (52.9)	0.78
Pneumonia	38 (55.9)	30 (58.8)	8 (47.1)	0.40
Rebleeding	30 (44.1)	19 (37.3)	11 (64.7)	0.048

p-values: chi-square test. Group comparisons were calculated from the reported counts.

5.5 Predictors of Outcome

In the multivariable model (Table 4), treatment modality was the only significant predictor of GOS outcome ($p = 0.001$). Age, sex, hypertension, diabetes and hematoma volume category were not. The confidence interval for treatment was very wide (3.58–100.05).

Table 4. Multivariable Logistic Regression for Good GOS Outcome

Variable	Adjusted OR*	95% CI	p-value
Treatment (craniotomy vs conservative)	18.93	3.58–100.05	0.001
Age category	0.68	0.33–1.41	0.299
Sex	0.68	0.17–2.70	0.586
Hypertension	0.90	0.19–4.37	0.897
Diabetes mellitus	1.14	0.29–4.49	0.848
Hematoma volume category (<30 vs >30 mL)	1.01	0.21–4.83	0.987

OR, odds ratio; CI, confidence interval. *Point estimates were derived from the 95% confidence limits.

5.6 DISCUSSION

Principal Findings

In this cohort of 68 patients, craniotomy was associated with better functional outcome than conservative management (good GOS outcome 86.3% vs 29.4%). Mortality was numerically lower (13.7% vs 35.3%) but the difference was not statistically significant ($p = 0.074$). Hospital and ICU stay were similar. These results must be read in the light of how treatment was allocated.

Patient Profile

Mean age (56.6 years) was close to that in other Indian series: 58.1 years in a large southern Indian cohort [3] and a median of 55 years in another [11]. Hypertension (75.0%) was more frequent than the 57.8% and 70% reported by Hegde et al. [3] and Peta and Mallela [4], and diabetes was present in 44.1%. These figures support community-level blood pressure control as a prevention target. Women made up 60.3% of our cohort, whereas most series report a male predominance, for example 70.5% men in Hegde et al. [3] and 82.4% men in a study of moderate to large hematomas [10]. Referral pattern, health-seeking behaviour or chance in a small sample may explain the difference. Presentation was often severe: mean GCS was 9.56, mean hematoma volume 37.2 mL and intraventricular extension was present in 39.7% (47% in [3]). Low GCS, large volume and intraventricular extension are established markers of poor prognosis [3,4,16].

Mortality

Three-month mortality (19.1%) was lower than the 28–30% reported in Indian cohorts [3,15]. Differences in case mix may contribute. The requirement for consent and the exclusion of patients lost to follow-up may also have favoured patients who survived the early period, and the small sample makes the estimate imprecise. Mortality rose from 10.3% at discharge to 19.1% at three months, so assessment at discharge alone would have understated deaths.

Craniotomy Versus Conservative Management

The lower mortality with surgery is in the same direction as the findings of Bhaskar et al. [9] and Hegde et al. [10], who studied patients with large hematomas. Unlike those studies, we also found a functional advantage. In contrast, STICH and STICH II found no overall benefit

from early surgery [6,7], Sharma et al. found no difference after adjustment for baseline severity [11], and Wang et al. reported better outcomes with conservative care in minor basal ganglia hemorrhage [13]. Our result should not be taken as proof that craniotomy improves outcome, for three reasons. First, allocation was clinical and not random. Every patient with a severe GCS was operated, and the groups also differed in hypertension. Second, the conservatively managed patients had milder admission GCS scores yet worse outcomes. This suggests that they differed in unmeasured ways, for example hemorrhage location, age, comorbidity, delay in presentation or a decision not to operate because of poor prognosis, rather than that conservative treatment is harmful. Third, the regression did not include GCS, intraventricular extension or hemorrhage location, and with only 19 poor outcomes for six covariates the model is likely over-fitted. The adjusted odds ratio for treatment (about 19) has a 95% confidence interval of 3.6 to 100 and is probably inflated. Confounding by indication is the most likely explanation for at least part of the difference. The mortality result was borderline: the uncorrected chi-square p -value was 0.050, but Fisher's exact test, which is appropriate because one expected cell count was 3.25, gave $p = 0.074$.

Complications

Pneumonia (55.9%), infection (50.0%) and rebleeding (44.1%) were frequent. Pneumonia was more common after craniotomy, as reported by Wang et al. [13] and in the small series of Rehman and Anwar [14], but our difference was not significant. Rebleeding was more frequent with conservative management (chi-square $p = 0.048$, Fisher's exact $p = 0.089$). Because three complications were compared without adjustment, this is an exploratory finding. The rebleeding rate is far higher than the 5.1% clot progression reported in a large southern Indian cohort [3]. The definition, imaging criteria and timing of rebleeding are not specified and should be defined in future work.

Strengths and Limitations

Strengths are prospective data collection at one institution with uniform imaging and care, two standard outcome scales, and reporting of complications. The main limitations are the non-randomised design with selection bias, a small sample without a power calculation, a single centre, and a regression model that omitted key prognostic variables. Hemorrhage location, midline shift and perihematomal oedema were recorded but not analysed. Definitions of the complications were not specified. Follow-up was limited to three months, and heterogeneity within each group (surgical technique, timing and conservative regimen) was not examined.

6. CONCLUSION

In this single-centre observational study of 68 patients with ICH, craniotomy was associated with better functional outcome than conservative management, and with numerically lower but not significantly different mortality. Treatment was allocated according to severity, and the analysis did not adjust for baseline GCS, hematoma characteristics or location. These associations should therefore not be interpreted as a treatment effect. Pneumonia, infection and rebleeding were common in both groups and call for careful perioperative and critical care. The choice between craniotomy and conservative management should remain individualised.

7. Future Scope

Larger multicentre prospective studies, ideally randomised, are needed. They should apply explicit selection criteria based on GCS, hematoma volume, location, intraventricular extension and age, and should adjust for these factors or use propensity methods. Complications should be defined by standard criteria in advance. Follow-up should extend to six or twelve months and include quality-of-life measures. Minimally invasive evacuation should be compared with craniotomy in the same setting.

Declarations

Ethics Approval: approved by the Institutional Ethics Committee, L.N. Medical College and Research Centre, Bhopal.

Consent: written informed consent was obtained from all participants or their legally authorised representatives.

Conflict of Interest: none declared.

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Data Availability: the data are available from the corresponding author on reasonable request.

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