Article published online: 2023-12-14

Surgical Outcome of Basal Ganglia Hemorrhage: A Retrospective Analysis of Nearly 3,000 Cases over 10 Years

Darpanarayan Hazra[1] Gina M. Chandy[2] Amit K. Ghosh[3]

[1] Department of Emergency Medicine, Institute of Neurosciences, Kolkata, West Bengal, India
[2] Department of Emergency Medicine, Christian Medical College and Hospital, Vellore, Tamil Nadu, India
[3] Department of Neurosurgery, Institute of Neurosciences, Kolkata, West Bengal, India

Asian J Neurosurg 2023;18:742–750.

Address for correspondence Darpanarayan Hazra, MBBS, FAEM, Department of Emergency Medicine, Institute of Neurosciences, Kolkata 700017, West Bengal, India (e-mail: drdarpahazra@gmail.com).

Gina M. Chandy, MBSS, MD, Department of Emergency Medicine, Christian Medical College and Hospital, Vellore 632004, Tamil Nadu, India (e-mail: ginachandy@gmail.com).

Abstract

Background Basal ganglia hemorrhage (BGH) is a severe neurologic condition associated with significant morbidity and mortality, and its optimal management remains a topic of debate. Our study assessed the surgical outcomes of BGH patients at the 3-month mark using the modified Rankin Scale (mRS).

Methods This retrospective observational study was conducted over 10 years at an advanced neuro-specialty hospital in Eastern India, including patients who underwent decompressive craniotomy and hematoma evacuation. Variables were systematically coded and analyzed to evaluate the postoperative outcome with age (in years), preoperative motor (M) status, and hematoma volume.

Results This study enrolled 2,989 patients with a mean age of 59.62 (standard deviation: 9.64) years, predominantly males ($n = 2{,}427$; 81.2%). Hypertension (1,612 cases) and diabetes mellitus (1,202 cases) were the most common comorbidities. Common clinical presentations included ipsilateral weakness (1,920 cases) and/or altered mental status (1,670 cases). At the 3-month mark postsurgery, 2,129 cases (71.2%) had a favorable outcome based on mRS, while 389 cases (13.0%) had an unfavorable outcome. The regression equation showed that age was inversely related to the percentage of individuals achieving a favorable outcome. It also revealed that the preoperative motor score was positively correlated with favorable outcomes. Hematomas smaller than 60 mL had better outcomes, with 1,311 cases (69.1%) classified as good outcomes and 337 cases (17.8%) as bad outcomes. Fatal outcomes related to the illness were observed in 471 patients (15.8%) within the study population.

Conclusion Surgery for BGH showed a substantial improvement in outcomes, particularly in patients with M5/M4 motor status. The preoperative motor score (M status) emerged as a crucial predictor of favorable neurological outcomes. Age and hematoma volume, however, were found to be nondefinitive factors in determining good outcomes.

Keywords
- basal ganglia hemorrhage
- decompressive craniotomy
- thalamic hemorrhage
- decompressive craniectomy
- hematoma evacuation

article published online December 14, 2023

DOI https://doi.org/10.1055/s-0043-1776049.
ISSN 2248-9614.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

Introduction

Basal ganglia hemorrhage (BGH) is a relatively common subtype of stroke, representing approximately 10 to 15% of all intracerebral hemorrhage (ICH).[1,2] It is more common in older individuals, particularly those aged between 60 and above, and tends to affect men more than women.[3,4] Hypertension and diabetes mellitus are among the most common risk factors. Certain lifestyle factors, such as smoking and excessive alcohol consumption, have been associated with an increased likelihood of developing this condition.[5,6] It can manifest with various symptoms, with unilateral weakness of the body often being the common presentation. Individuals may either/or experience headaches, nausea, vomiting, and a depressed mental state. In severe instances, patients may present in a comatose or severely obtunded state.[5,7] Timely and effective management of these patients after presentation to the emergency room (ER) is essential to prevent clinical deterioration. This involves stabilization of the patient's airway, breathing, circulation, and regular reassessment. Rapid and precise diagnosis should be achieved by using neuroimaging techniques. Targeted assessments are performed to identify potential early interventions, such as controlling elevated blood pressure, correcting coagulopathy, and assessing the need for early surgical intervention.[7–9]

The crucial aspect of clinical management for BGH is to promptly alleviate the compression caused by the hematoma and restore the functionality of the affected nerve cells by either surgical or conservative interventions. These comprehensive approaches form the foundation for the effective management of patients during the critical "golden hour" following a BGH.[7–9] Various surgical approaches are utilized for the management of BGH, including standard craniotomy, decompressive craniectomy (DC), endoscopic hematoma evacuation, and minimally invasive techniques like stereotactic catheter-directed thrombolytic agent injection or endoscope-assisted hematoma evacuation through a keyhole approach.[10–13] Craniotomy and hematoma evacuation are commonly preferred by surgeons, especially for large hematomas, due to their favorable outcomes.[14] This procedure entails the removal of a bone flap to allow the swollen brain to expand outward, preventing brain herniation. Early hematoma clearance significantly contributes to improving neurological function and minimizing secondary brain damage. Moreover, the procedure offers additional benefits such as reducing intracranial pressure (ICP) and enhancing cerebral compliance, cerebral oxygen supply, and cerebral blood perfusion, ultimately leading to improved patient prognosis.[14–16]

This retrospective observational study was conducted in India to summarize the outcomes of DC and hematoma evacuation for BGH over 10 years. The findings of this study not only contribute to the existing literature on the subject but also add to the larger discussion surrounding this condition.

Materials and Methods

Study Setting and Design

This retrospective observational study was conducted in an advanced neurological hospital located in Eastern India. The hospital, equipped with 195 beds, provides comprehensive care for both neurosurgical and medical cases.

Study Period

From August 1, 2008 to August 30, 2018—the study spanned 10 years.

Variables

Patients' data were retrieved from the medical records of inpatients. A standardized data collection sheet was used to record the demographic and baseline characteristics of the participants, which encompassed symptoms experienced at presentation, vital signs, and past medical history. Additionally, preoperative motor power, computed tomography (CT) scan findings, and the location of the bleeding were documented. Hematoma volume was estimated using the ABC/2 method, where A represents the maximum length (in cm), B indicates the width on the same head CT slice that is perpendicular to A, and C is derived by multiplying the number of slices by the slice thickness.[17] Notable outcomes were assessed in the ER, intensive care unit (ICU), and hospital settings. Postoperative outcomes at 3 months were assessed using the modified Rankin Scale (mRS). These categories included favorable/good (mRS 2, 3), unfavorable/bad/poor (mRS 4, 5), and moribund (mRS 6) outcomes.

Participants

The study included consecutive patients (age $<$ 70 years) undergoing DC/craniectomy with a BGH volume exceeding 30 mL and a motor power ranging from M2 to M5 who presented to the ER and met the following CT criteria: hemorrhage localized outside the internal capsule (class I), extension to the anterior limb of the internal capsule (class II), and extension to the posterior limb of the internal capsule (class IIIa). The study excluded participants who met any of the following criteria: age exceeding 70 years, motor scores of M1 and M6, or being aphasic but awake and alert. Based on the CT criteria, exclusion criteria included extension to the posterior limb of the internal capsule with massive ventricular hemorrhage (class IIb), extension to both anterior and posterior limbs of the internal capsule without ventricular hemorrhage (class IVa), extension to both anterior and posterior limbs of the internal capsule with massive ventricular and thalamus hemorrhage (class IVb), and hemorrhage extending to the thalamus and subthalamus (class V). Additionally, patients with a hematoma volume of less than 30 mL were excluded. The preponderance of this cohort manifested with hypertension-induced bleeding. In cases where patient stability obviated the immediate need for surgical intervention, CT angiograms were performed as a diagnostic modality to ascertain the absence of arteriovenous malformation (AVM), aneurysm, vasculitis, tumor, or moyamoya disease. When a heightened suspicion of AVM or aneurysm arose, a digital subtraction angiogram (DSA) was conducted, given its reported association with 8 to 18% of BGH cases. Patients identified as requiring urgent surgical intervention underwent a postoperative CT angiogram to validate the absence of the aforementioned pathological conditions. Any patients in whom these pathological conditions were detected were subsequently excluded from the study. Furthermore, charts with missing data, patients presenting with BGH as a result of trauma and patients lost to follow-up at 3 months were also excluded from the study.

Surgical Technique

The patient was positioned supine with the head turned 30 to 45 degrees contralaterally on a specialized head ring. An incision, meticulously shaped like a question mark, was initiated, originating from the commencing from the anterior hairline, 2 cm from the midline. This incision was then extended posteriorly to a point 5 cm behind the posterior margin of the ear, then curved downward, proceeded anteriorly, and curved downward again until reaching the root of the zygoma. To ensure utmost safety, a precise marking of the midline was executed, and the incision was carefully placed approximately 2 cm lateral to the midline, thus averting potential harm to the superior sagittal sinus. Special consideration was given to the superficial temporal artery, which customarily lies approximately 1 cm anterior to the tragus. The bone flap, measuring more than 15 cm in anteroposterior diameter, extended downward to the floor of the temporal fossa, thus facilitating adequate decompression. The specific locations and quantities of burr holes were contingent upon the surgeon's individual preferences and experience; nevertheless, the senior author found three holes to be sufficient. These burr holes were strategically placed as follows: (1) on the temporal squama, (2) in the parietal area just posterior to the parietal bone and near the skin incision, and (3) in the keyhole area behind the zygomatic arch of the frontal bone. Hemostasis of the scalp was effectively achieved through the utilization of Ranney clips. The scalp flap was meticulously retracted with the aid of a specialized fish-hook instrument. Thereafter, detachment and subsequent retraction of the temporalis muscle from the bone were performed. Subsequently, a craniotomy was conducted by connecting the previously created burr holes, with a portion of the temporal bone being excised to the extent of the skull base to ensure comprehensive decompression of the temporal lobe. The dura mater was opened in a stellate fashion, although in many cases it was opened in a "C" shape, depending on the location of the hematoma. Cortisectomy was performed when the hematoma was closest to the cortex and over the noneloquent gyrus. The evacuation of the hematoma was accomplished under microscopic guidance using gentle suction and spatula techniques, followed by gentle irrigation and suction. Hemostasis was achieved using bipolar coagulation, topical hemostatic agents, and flowable gelatin with thrombin as necessary. Upon achieving hemostasis, a lax duraplasty was performed using a dural substitute. The operative wound was meticulously closed in layers, a corrugated drain was placed, and the bone flap was either stored in the anterior abdominal wall or within the institute's bone bank.[18]

Hospital Stay

Following surgery, each patient was kept on a minimum of 24 hours of elective ventilation and was gradually weaned off based on their clinical condition (►**Fig. 1**). Subsequently, a tracheostomy was performed, and the process of ventilator weaning commenced. A repeat CT scan was conducted 12 hours after the surgery, or earlier if the patient's clinical condition worsened, to assess the surgical outcome. Prophylactic antiepileptic drugs and antibiotics (minimum duration of 7 d) were initiated for each patient. To achieve optimal blood pressure control, one or multiple antihypertensive drugs were used. Injection mannitol was administered in cases where signs of brain edema persisted clinically or in the subsequent CT scan. All patients received dedicated critical care, nursing support, and rehabilitation services such as limb physiotherapy and chest physiotherapy. The patients were gradually transitioned from the ICU to the high-dependency unit and eventually to regular ward beds, guided by their hemodynamical and clinical condition (►**Fig. 1**).

Data Source and Statistical Analysis

The data were initially recorded in Microsoft Excel version 16.65, and subsequent statistical analysis was conducted using IBM SPSS Statistics for Windows (version 25.0, Armonk, New York, United States), a software package specifically designed for social sciences. Age, hematoma volume, and preoperative motor status were coded as factors. The probability of a favorable or unfavorable outcome was determined using the A intersection B formula ($A \cap B = [x: x € A \text{ and } x € B]$). A regression equation was used to examine the relationship between age, preoperative motor score, and the percentage of patients achieving a favorable outcome.

Ethical Considerations

The study was initiated after obtaining permission from the institutional review board and ethics committee. Due to the retrospective nature of the study, which did not involve the disclosure of any individual's data, a waiver of consent was obtained from the institutional review board.

Results

Baseline and Demographic Characteristics

Our study group consisted of 2,989 patients with a mean age of 59.62 (standard deviation: 9.64) years, with a predominance of males ($n = 2{,}427$; 81.2%). The distribution of ages was as follows: 796 patients aged between 30 and 40 years, 992 patients aged between 41 and 50 years, 1,010 patients aged between 51 and 60 years, and 191 patients aged between 61 and 70 years. The majority of patients had a preexisting history of hypertension (1,612 cases), followed by diabetes mellitus (1,202 cases), reactive airway disease (412 cases), ischemic heart disease or other cardiac ailments (367 cases), and chronic kidney disease (9 cases). The main

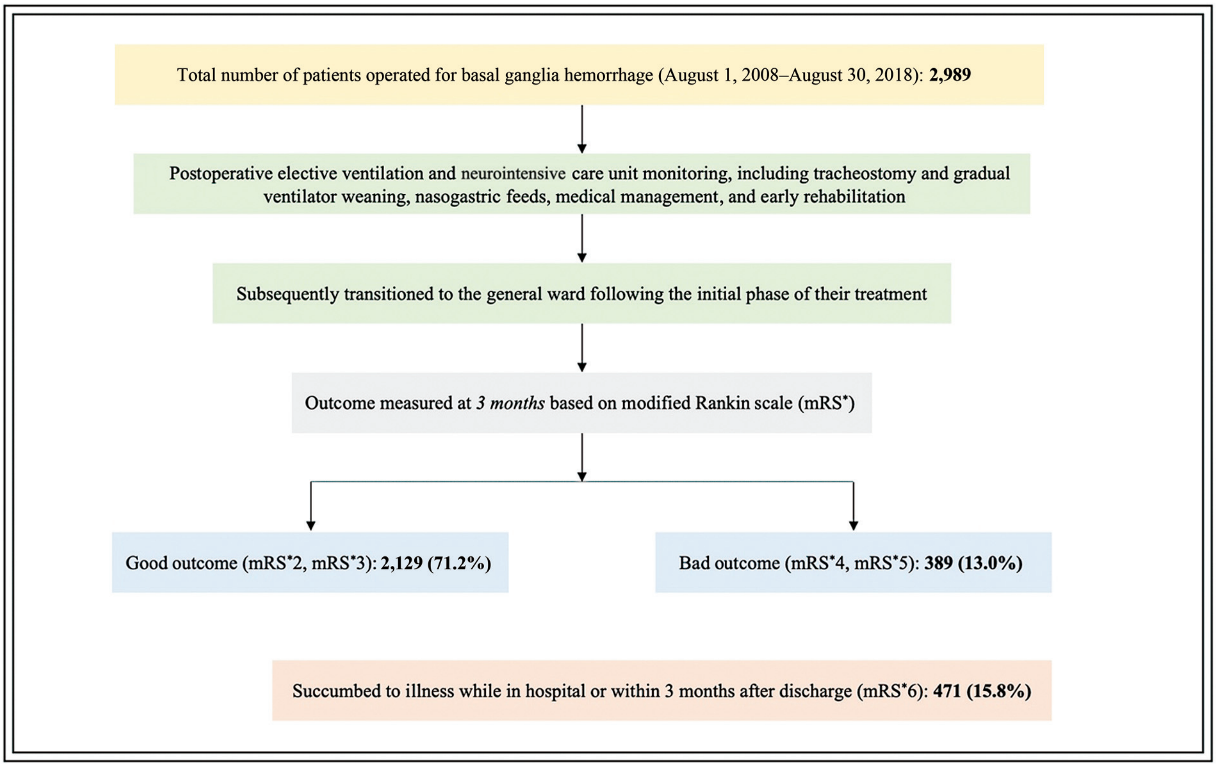

Fig. 1 The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement. mRS*: modified Rankin Scale

clinical presentations were ipsilateral weakness (1,920 cases) and/or altered mental status (1,670 cases). For further details on the remaining clinical presentations and vital signs at the presentation, please refer to ►**Table 1**.

Emergency Room Management and Disposition

Upon presentation to the ER, a comprehensive and meticulous clinical and physical examinations were conducted, and subsequent management was carried out accordingly. Due to factors such as poor Glasgow Coma Scale, tongue drop, or imminent arrest few patients ($n = 412$; 13.8%) required invasive ventilation in the ER. The decision regarding surgical intervention was made by the on-call neurosurgeon following neuroimaging. However, we included patients with inclusion criteria for the study encompassing patients meeting the aforementioned criteria. Each patient received an antiepileptic drug, measures to counteract brain edema, one or more hypertensive medications, the initial dose of antibiotics, and other supportive care. Following stabilization in the ER, patients were transferred to the dedicated ICU or operating room based on their clinical condition or the CT scan findings.

The Outcome of Surgery

A favorable postoperative outcome, as determined using the mRS at the 3-month mark following surgery, was observed in 2,129 cases (71.2%), while an unfavorable outcome was observed in 389 cases (13.0%; ►**Fig. 1**). Outcome as assessed by mRS (3 months postictus) was evaluated in relation to age (in years), preoperative motor (M) status, and hematoma volume and is presented in ►**Table 2**. By utilizing the regression equation (G: [−1.3215; age + 126.24]), it was observed that there exists an inverse relationship between age and the percentage of individuals achieving a favorable outcome (►**Fig. 2**). An analysis of postoperative motor score compared to preoperative motor outcomes revealed that a significant majority of patients who exhibited pain localization (M5) ($n = 1645$; 55.0%) during the preoperative period achieved favorable outcomes, followed by those who demonstrated pain flexion (M4; $n = 967$; 32.4%; ►**Table 2**). Conversely, patients presenting with lower motor power (M3, M2) exhibited poorer outcomes. Subsequently, the regression equation (G: 30.694 [preoperative motor score]: 60.748: R^2: 0.827) demonstrated a positive correlation between the preoperative motor score and the percentage of patients achieving a favorable outcome. Specifically, as the preoperative motor score increased from M2 to M5, there was an observed increase in the percentage of individuals attaining a good outcome. This relationship is depicted in ►**Fig. 3**. Upon analyzing the BGH volume, it became evident that outcomes were favorable for hematomas measuring less than 60 mL. Among such cases, 1,311 (69.1%) were classified as good outcomes, while 337 (17.8%) were categorized as bad outcomes. Conversely, when the hematoma volume surpassed 60 mL, the majority of cases ($n = 818$; 74.9%) displayed a good outcome, while 221 (20.3%) succumbed to their illness. Furthermore, the probability of achieving good or poor surgical outcomes, as determined by the A∩B formula, is given in ►**Tables 3** and **4**.

Within the studied population, a cumulative number of 471 (15.8%) patients experienced fatal outcomes related to

Table 1 Baseline characteristics, clinical symptoms, and vital signs at presentation

Variables	Frequency (%)
Age (SD) years	59.62 (9.64)
Gender	
Male	2,427 (81.2)
Female	562 (18.8)
Preexisting illnesses (one or more)	
Hypertension	1,612 (53.9)
Diabetes mellitus	1,202 (40.2)
Reactive airway disease	412 (13.8)
Ischemic heart disease or other heart ailments	367 (12.3)
Chronic kidney disease	9 (0.3)
On anticoagulation or antiplatelet drugs due to underlying disease	512 (17.1)
Most common clinical presentations (usually more than one symptom)	
Numbness or weakness on one side of the face or the body	1,920 (64.2)
Altered mental status	1,670 (55.9)
Slurring of speech	1,421 (47.6)
Vomiting/nausea	899 (30.1)
Intense headache	767 (25.7)
Lack of coordination or balance	412 (13.8)
Bowel or bladder incontinence	208 (6.9)
Motor (M) score	
Localizes pain (M5)	1,645 (55.0)
Withdrawal from pain (M4)	967 (32.4)
Flexion to pain (M3)	331 (11.1)
Extension to pain (M2)	46 (1.5)
Vital signs at presentation to the emergency room	
Systolic blood pressure $\geq$ 150 mm Hg	1,581 (52.9)
Pulse rate (IQR)	66 (78, 112)
Respiratory rate $\geq$ 30	998 (33.4)
O_2 saturation <88% in room air	765 (25.6)
Tongue fall/noisy breathing/grunting	486 (16.3)

Abbreviations: IQR, interquartile range; SD, standard deviation.

their illnesses. The most commonly recorded cause of death as mentioned in the medical records was neurological deterioration (236), ventilator-associated or hospital-acquired pneumonia (86), meningitis (62), rebleeding (41), cardiac events (42), and probable pulmonary embolism (4).

Discussion

Early recognition and prompt management of patients with BGH are vital due to the high likelihood of rapid deterioration.[19] The effectiveness of neurosurgical intervention remains uncertain despite discussions in recent multicentric studies.[11–13] Nevertheless, advancements in surgical techniques, neuroimaging, neuroanesthesia techniques, and postoperative care have contributed to improved surgical outcomes. This study offers important insights into the management and consequences of this disorder, comprising one of the biggest cohorts of BGH patients in Asia and India. Our findings align with previous research conducted in Western and European countries, as we observed similar mean age, gender distribution, and prevalent comorbidities within our population.[5,12]

A DC is commonly employed as a standard approach, particularly for hematomas larger than 30 mL.[14] This intervention aims to mitigate the detrimental effects of blood and plasma products, alleviate surrounding ischemia and edema, and prevent further expansion of the hematoma.[14,15] Additionally, an early procedure can effectively reduce ICP and enhance local blood circulation, leading to significant improvements.[19–22] Moreover, it offers advantages such as providing a clear view and complete removal of the hematoma, facilitating easier hemostasis, and ultimately contributing to better outcomes, reduced mortality rates, and improved prognosis.

Emergency Room Management and Patient Selection

The selection of patients is a crucial aspect of having a favorable surgical outcome. It involves rapid clinical examination and neuroimaging techniques such as CT scans to accurately identify the location of ICH (Class I; level of evidence A).[22] Additionally, a CT angiogram and contrast-enhanced CT scan to assess the risk of hematoma expansion and rule out the presence of basal ganglia AVMs should also be considered (Class IIb; level of evidence B).[22] Notably, AVMs, which account for 10 to 34% of BGHs, were excluded from our study.[23,24] The administration of prophylactic antiseizure medication is not recommended based on the recent updates (class III; level of evidence B).[22] However, contrary to these recently established recommendations, we have administered prophylactic antiepileptic drugs that should have been avoided. Additionally, it should be observed that encountering young individuals with both significant BGH and a motor power score of M6 is uncommon. However, such a clinical scenario may be observed among elderly patients, primarily due to cerebral atrophy. In patients aged over 80 years, conservative management is typically offered at our center based on the mortality concept, with the ultimate decision regarding treatment left to the discretion of the patient's family. Conversely, for patients under the age of 70 years presenting with BGH and a motor power score of M6, we post them for elective surgery or emergency if the clinical condition deteriorates, as the risk of perihematomal edema progressively escalates with each passing day. Furthermore, M6 patients under 60 years of age without atrophic brains and a hematoma volume exceeding 30 mL underwent immediate surgery, whereas M6 patients over 60 years old with brain atrophy were closely monitored, and surgery was considered in case of deterioration. It's important to note that our study only included patients with motor power scores of M5 and below at presentation.

Table 2 Postoperative outcome as assessed by the modified Rankin Scale (3 months postictus) was evaluated in relation to age (in years), preoperative motor (M) status, and hematoma volume

Variable	Frequency, $n = 2,989$ (%)	Good[a] outcome $n = 2,129$ (71.2%)	mRS[b] 2	mRS[b] 3	Bad[c] outcome $n = 389$ (13.0%)	mRS[b] 4	mRS[b] 5
Age group							
30 to 40 years	796 (26.6)	630 (79.2%)	486	144	166 (20.9)	102	64
41 to 50 years	992 (33.2)	664 (66.9%)	452	212	157 (15.8%)	114	43
51 to 60 years	1,010 (33.8)	780 (77.3%)	592	188	30 (2.9%)	12	18
61 to 70 years	191 (6.4)	55 (28.8%)	02	53	36 (18.8%)	3	33
Preoperative Motor (M) status							
Localizes pain (M5)	1,645 (55.0)	1465 (89.1%)	1312	153	109 (6.6%)	72	37
Withdrawal from pain (M4)	967 (32.4)	638 (65.9%)	482	156	129 (13.3%)	117	12
Flexion to pain (M3)	331 (11.1)	18 (5.4%)	5	13	113 (34.1%)	35	78
Extension to pain (M2)	46 (1.5)	8 (17.4%)	1	7	38 (82.6%)	4	34
Hematoma volume							
30 to 60 mL	1,898 (63.5)	1311 (69.1%)	1021	290	337 (17.8%)	104	233
More than 60 mL	1,091 (36.5)	818 (74.9%)	501	317	52 (4.8%)	8	44

Outcome: Patients who achieved a *good*[a] outcome were identified by a modified Rankin Scale (mRS[b]) score of either, 2 indicating a slight disability but capable of independently managing personal affairs, or, 3 indicating a moderate disability but still able to walk unassisted, albeit with some assistance. Conversely, patients were considered to have a bad[c] outcome if their mRS[b] score was either, 4 reflecting moderately severe disability with an inability to walk or attend to bodily needs without assistance, or 5 representing severe disability with being bedridden, incontinent, and requiring constant nursing care and attention. A total of 471 (15.8%) individuals succumbed to their illness, primarily during their hospitalization or within 3 months following discharge. Therefore, these cases were excluded from the table.

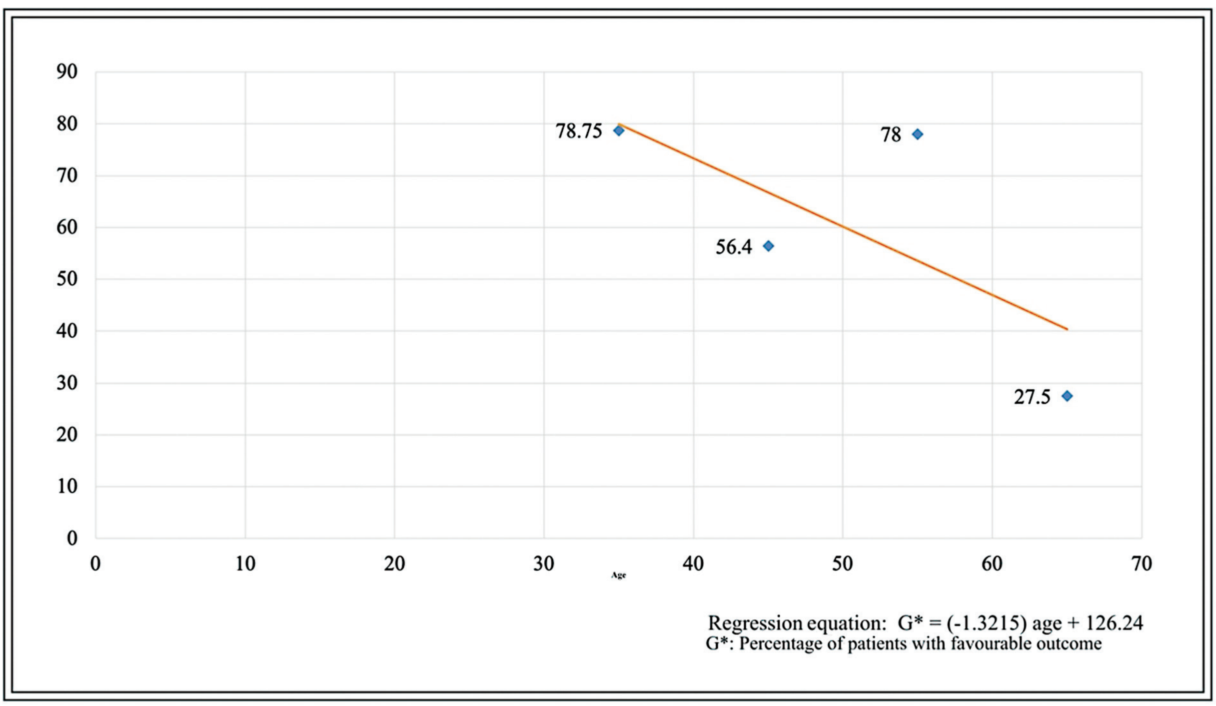

Fig. 2 The regression equation assessing the relationship between the percentage of patients with a good* outcome and age.

Based on this extensive cohort study involving nearly 3,000 patients, it is evident that the preoperative motor score (M status) is the most significant predictor of favorable neurological outcomes in cases of BGH. Surgery performed when the patient's motor status is at M5 or M4 yields significant improvements in outcomes as also reported earlier.[10,11,14] Moreover, in this study group, it is notable that younger patients demonstrated a favorable prognosis, while the prognosis deteriorated with increasing age. This observation can potentially be attributed to the fact that

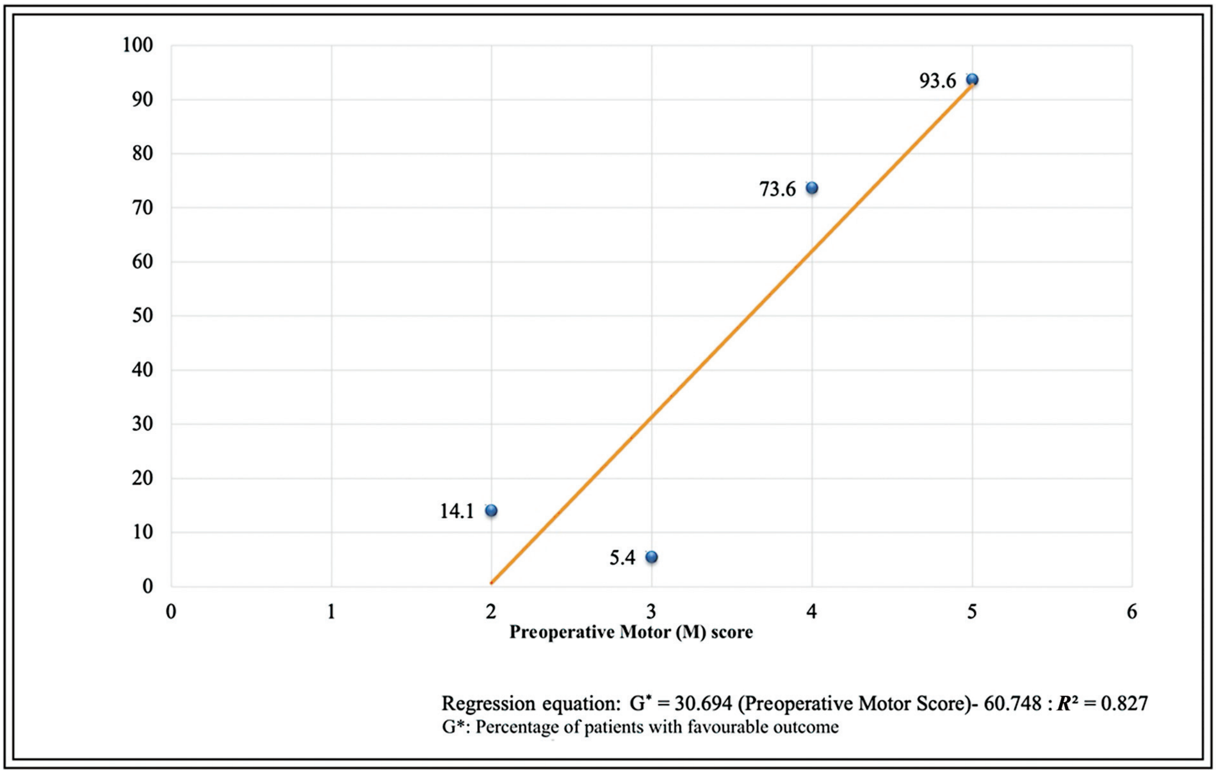

Fig. 3 The regression equation assessing the relationship between the percentage of patients with a good* outcome and preoperative motor (M) score.

Table 3 Probability of good[a] outcome after surgery based on age, preoperative motor score, and hematoma volume as determined by the A∩B formula

Age group	Preoperative motor score	Hematoma volume (mL)	Probability of good[a] outcome after surgery based on mRS[b]	
30 to 50 years	M4, M5	30 to 60	0.53	53%
30 to 50 years	M4, M5	More than 60	0.11	11%
30 to 50 years	M2, M3	30 to 60	0.013	1.3%
30 to 50 years	M2, M3	More than 60	0.005	0.5%
51 to 70 years	M4, M5	30 to 60	0.305	30.5%
51 to 70 years	M4, M5	More than 60	0.324	32.4%
51 to 70 years	M2, M3	30 to 60	0.028	2.8%
51 to 70 years	M2, M3	More than 60	0.0375	3.75%

Good[a] outcome: Patients were predicted to have a good[a] outcome if their modified Rankin Scale (mRS[b]) score was either 2 (indicating slight disability with the ability to manage personal affairs without assistance) or 3 (indicating moderate disability with the ability to walk without assistance but requiring some help).

younger patients had fewer medical comorbidities and potentially possessed greater immunity or physical strength, enabling them to recover more quickly. Upon conducting further analysis to assess the likelihood of a favorable outcome based on hematoma size and age, it became evident that neither factor alone should be regarded as absolute criteria for predicting a positive outcome. This finding also emphasizes the importance of assessing the motor status as a primary factor when determining the potential success of surgical intervention for BGH.

In light of the severity and intricate nature of the evolving disability associated with this condition, it is strongly recommended that comprehensive multidisciplinary rehabilitation services be accessible to all these patients.[22] When feasible, early rehabilitation interventions were initiated for each of these patients, ensuring their continuation within a well-coordinated program that facilitates accelerated hospital discharge and promotes home-based resettlement. This approach played a crucial role in supporting ongoing recovery, with a planned 15-day follow-up in the outpatient

Table 4 Probability of bad[a] outcome after surgery based on age, preoperative motor score, and hematoma volume as determined by the A∩B formula

Age group	Preoperative motor score	Hematoma volume (mL)	Probability of bad[a] outcome after surgery based on mRS[b]	
30 to 50 years	M4, M5	30 to 60	0.026	2.6%
30 to 50 years	M4, M5	More than 60	0.013	1.3%
30 to 50 years	M2, M3	30 to 60	0.129	12.9%
30 to 50 years	M2, M3	More than 60	0.167	16.7%
51 to 70 years	M4, M5	30 to 60	0.1575	15.75%
51 to 70 years	M4, M5	More than 60	0.098	9.8%
51 to 70 years	M2, M3	30 to 60	0.039	3.9%
51 to 70 years	M2, M3	More than 60	0.009	0.9%

Bad[a] outcome: Patients were predicted to have a bad[a] outcome (mRS[b]) score was either 4 (indicating moderately severe disability with the inability to walk or attend to bodily needs without assistance) or 5 (indicating severe disability with being bedridden, incontinent, and requiring constant nursing care and attention). Patients with mRS of 6 were excluded from the analysis.

department for the first 3 months or an immediate ER visit based on the clinical condition of the patient.

Limitations

This study has several limitations. First, there was no comparative arm (conservative management) available for evaluating outcomes, which limits the ability to make direct comparisons. Second, the study was conducted in a specialized neuro care referral center, which introduces the potential for referral pattern bias. Additionally, the reliance on medical records posed challenges due to inconsistent data maintenance, resulting in the exclusion of certain data from the analysis. Lastly, the assessment of outcomes was conducted at the 3-month mark, as a significant number of patients were lost to follow-up or lacked proper documentation thereafter.

Conclusion

DC and evacuation of hematoma in cases of BGH demonstrated a significant positive impact on outcomes when performed on patients with M5/M4 motor status. The preoperative motor score (M status) emerged as a crucial predictor for achieving a favorable neurological outcome in the case of BGH. Age, on the other hand, was found to be a nonabsolute criterion for determining good outcomes. Similarly, hematoma volume was also deemed a nonabsolute criterion for predicting favorable outcomes.

Authors' Contributions

D.H. contributed to concepts, design, definition of intellectual content, literature search, manuscript preparation, manuscript editing, and manuscript review. G.M.C. helped in design, definition of intellectual content, literature search, manuscript preparation, manuscript editing, and manuscript review. A.K.G. was involved in concepts, definition of intellectual content, manuscript editing, and manuscript review. He also provided guarantee.

Funding
None.

Conflict of Interest
None declared.

Acknowledgments
Thanks to Department of Emergency Medicine, Neuroradiology, Neurosurgery, Neuroanesthesia, Neuro Critical Care and Neuro-rehabilitation Therapy; Institute of Neurosciences Kolkata, 185/1 A.J.C. Bose Road, Kolkata 700017.

References

1 Ziai WC, Carhuapoma JR. Intracerebral hemorrhage. Continuum (Minneap Minn) 2018;24(06):1603–1622
2 Rajashekar D, Liang JW. Intracerebral hemorrhage. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2023
3 Caceres JA, Goldstein JN. Intracranial hemorrhage. Emerg Med Clin North Am 2012;30(03):771–794
4 Hsieh JT, Ang BT, Ng YP, Allen JC, King NKK. Comparison of gender differences in intracerebral hemorrhage in a multi-ethnic Asian population. PLoS One 2016;11(04):e0152945
5 An SJ, Kim TJ, Yoon BW. Epidemiology, risk factors, and clinical features of intracerebral hemorrhage: an update. J Stroke 2017;19 (01):3–10
6 Ariesen MJ, Claus SP, Rinkel GJE, Algra A. Risk factors for intracerebral hemorrhage in the general population. Stroke 2003;34(08): 2060–2065
7 Hemphill JC III, Greenberg SM, Anderson CS, et al;American Heart Association Stroke Council Council on Cardiovascular and Stroke Nursing Council on Clinical Cardiology. Guidelines for the management of spontaneous intracerebral hemorrhage: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2015;46(07): 2032–2060
8 Kreitzer N, Woo D. Overview of Hemorrhagic Stroke Care in the Emergency Unit. In: Lee SH, ed. Stroke Revisited: Hemorrhagic Stroke. Singapore: Springer; 2018:91–101
9 Canadian Stroke Best Practices [Internet]. [cited 2023 Jun 27]. 1. Emergency Management of Intracerebral Hemorrhage. Accessed

September 26, 2023 at: https://www.strokebestpractices.ca/en/recommendations/management-of-intracerebral-hemorrhage/emergency-management-of-intracerebral-hemorrhage/

10 Mendelow AD, Teasdale GM, Barer D, Fernandes HM, Murray GD, Gregson BA. Outcome assignment in the International Surgical Trial of Intracerebral Haemorrhage. Acta Neurochir (Wien) 2003; 145(08):679–681, discussion 681

11 Fu C, Wang N, Chen B, et al. Surgical management of moderate basal ganglia intracerebral hemorrhage: comparison of safety and efficacy of endoscopic surgery, minimally invasive puncture and drainage, and craniotomy. World Neurosurg 2019;122:e995–e1001

12 Guo W, Liu H, Tan Z, et al. Comparison of endoscopic evacuation, stereotactic aspiration, and craniotomy for treatment of basal ganglia hemorrhage. J Neurointerv Surg 2020;12(01):55–61

13 Jianhua X, Zhenying H, Bingbing L, et al. Comparison of surgical outcomes and recovery of neurologic and linguistic functions in the dominant hemisphere after basal ganglia hematoma evacuation by craniotomy versus endoscopy. World Neurosurg 2019; 129:e494–e501

14 Kolias AG, Kirkpatrick PJ, Hutchinson PJ. Decompressive craniectomy: past, present and future. Nat Rev Neurol 2013;9(07): 405–415

15 Mohan M, Layard Horsfall H, Solla DJF, et al;NIHR Global Health Research Group on Neurotrauma. Decompressive craniotomy: an international survey of practice. Acta Neurochir (Wien) 2021;163 (05):1415–1422

16 de Oliveira Manoel AL. Surgery for spontaneous intracerebral hemorrhage. Crit Care 2020;24(01):45

17 The ABCs of Measuring Intracerebral Hemorrhage Volumes | Stroke [Internet]. [cited 2023 Jun 27]. Accessed September 26, 2023 at: https://www.ahajournals.org/doi/full/10.1161/01.STR.27.8.1304

18 Ghosh AK. Different methods and technical considerations of decompressive craniectomy in the treatment of traumatic brain injury: a review. Indian J Neurosurg 2017;06(01):36–40

19 Arboix A, Rodríguez-Aguilar R, Oliveres M, Comes E, García-Eroles L, Massons J. Thalamic haemorrhage vs internal capsule-basal ganglia haemorrhage: clinical profile and predictors of in-hospital mortality. BMC Neurol 2007;7:32

20 Kellner CP, Schupper AJ, Mocco J. Surgical evacuation of intracerebral hemorrhage: the potential importance of timing. Stroke 2021;52(10):3391–3398

21 Sahuquillo J, Dennis JA. Decompressive craniectomy for the treatment of high intracranial pressure in closed traumatic brain injury. Cochrane Database Syst Rev 2019;12(12):CD003983

22 Greenberg SM, Ziai WC, Cordonnier C, et al;American Heart Association/American Stroke Association. 2022 Guideline for the management of patients with spontaneous intracerebral hemorrhage: a guideline from the American Heart Association/American Stroke Association. Stroke 2022;53(07):e282–e361

23 Fleetwood IG, Marcellus ML, Levy RP, Marks MP, Steinberg GK. Deep arteriovenous malformations of the basal ganglia and thalamus: natural history. J Neurosurg 2003;98(04):747–750

24 Stapf C, Mohr JP, Pile-Spellman J, Solomon RA, Sacco RL, Connolly ES Jr. Epidemiology and natural history of arteriovenous malformations. Neurosurg Focus 2001;11(05):e1

