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A Comprehensive Analysis of Etiology and Surgical Results in Spontaneous Intracerebral Hemorrhage Cases

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ABSTRACT
Spontaneous intracerebral hemorrhage (ICH) is a significant cause of stroke, leading to high mortality and morbidity. This study aims to analyze patient demographics, clinical history, surgical interventions, and postoperative outcomes in patients with spontaneous ICH. This retrospective cohort study involved 45 patients diagnosed with spontaneous ICH at a tertiary care center. Patient selection criteria included confirmed ICH diagnosis through neuroimaging, age over 18 years and exclusion of ICH due to trauma, aneurysm, or arteriovenous malformation. Data on demographics, clinical history, ICH characteristics, surgical interventions, and postoperative outcomes were collected. Statistical analysis involved descriptive statistics, chi-square tests and t-tests/ANOVA. Patient demographics indicated a mean age of 62.17 years and elevated systolic blood pressure (135.92 mmHg). ICH characteristics showed a mean hemorrhage size of 32.33 mL, with common locations being deep and cerebellar regions. Surgical interventions included 19 open craniotomies and 26 minimally invasive surgeries, with a low complication rate. Postoperative outcomes varied, with a mean recovery time of 32.17 days and significant improvements in neurological status assessed by the Modified Rankin Scale (mRS). The study provides insights into the characteristics and outcomes of patients with spontaneous ICH. It underscores the complexity of ICH management, highlighting the role of patient-specific factors in surgical decision-making and recovery. The findings suggest the need for personalized treatment approaches in the management of ICH.

INTRODUCTION

Spontaneous Intracerebral Hemorrhage (ICH) represents a critical and complex challenge in neurology and neurosurgery, characterized by its sudden onset and potentially devastating outcomes. This comprehensive analysis aims to delve deep into the etiological factors contributing to ICH while critically evaluating the surgical outcomes in these cases. Our study stands on the shoulders of prior research that has incrementally unraveled the complexities of ICH, yet gaps in understanding remain, particularly in the integration of etiological insights with surgical decision-making and outcomes.

Early studies, such as Broderick *et al*.[1], provided foundational data on the incidence and risk factors of ICH, emphasizing the role of hypertension and age. Subsequent research by Qureshi *et al*.[2] expanded on these findings, exploring the influence of race and geographical variations. These studies set the stage for understanding the diverse causes of ICH.

Surgical intervention, a critical aspect of managing ICH, has been the subject of extensive debate. The STICH trials Mendelow *et al*.[3] were pivotal in exploring the efficacy of early surgical intervention versus conservative management. While these trials provided valuable insights, they also highlighted the need for more nuanced understanding, particularly in different patient subgroups and hemorrhage characteristics.

More recently, advancements in neuroimaging and minimally invasive surgery have opened new avenues of exploration. Studies like the MISTIE trials Hanley *et al*.[4] have begun to address these aspects, offering a glimpse into the potential of personalized surgical approaches based on the etiology and location of hemorrhage. In synthesizing these diverse strands of research, our analysis seeks to create a more cohesive understanding of ICH. We aim to integrate etiological factors with surgical decision-making processes and outcomes, thereby providing a more comprehensive framework for managing this complex and life-threatening condition.

The primary aim of this study is to comprehensively analyze the etiological factors contributing to spontaneous intracerebral hemorrhage (ICH) and evaluate the outcomes of surgical interventions. We intend to identify key etiological contributors, assess the efficacy of various surgical techniques and explore how different patient subgroups respond to these treatments. The goal is to enhance understanding of ICH's origins, improve surgical intervention strategies, and inform clinical guidelines, ultimately leading to better patient outcomes and personalized treatment approaches.

MATERIALS AND METHODS

Study design: This is a retrospective cohort study involving 45 patients diagnosed with spontaneous intracerebral hemorrhage (ICH). Data was collected from patient records from a single tertiary care center.

Patient selection: Patients were included based on the. following criteria:

- Confirmed diagnosis of spontaneous ICH through neuroimaging (CT or MRI scans)
- Age 18 years or older
- Underwent surgical intervention for ICH
- Exclusion criteria included patients with ICH due to trauma, aneurysm, or arteriovenous malformation

Data collection: Patient demographics, clinical history, and details of the ICH (such as location, size, and cause if identifiable) were recorded. Surgical intervention details, including the type of surgery, date and any intraoperative complications, were documented. Postoperative outcomes were tracked for up to 6 months post-surgery, focusing on recovery, neurological status and any complications.

Surgical intervention: The surgical techniques employed were categorized as either traditional open craniotomy or minimally invasive surgery. The decision for the type of surgery was based on the surgeon's discretion and individual patient factors.

Outcome measures: The primary outcomes measured were:

- Neurological improvement or deterioration post-surgery, assessed using the Modified Rankin Scale (mRS)
- Complication rates during and post-surgery
- Mortality rate within 6 months post-surgery

Statistical analysis: Descriptive statistics were used to summarize patient characteristics. Comparative analyses between different surgical techniques and patient subgroups were performed using chi-square tests for categorical variables and t-tests or ANOVA for continuous variables. A $p>0.05$ was considered statistically significant. All statistical analyses were conducted using [Specify Statistical Software].

Ethical considerations: The study was approved by the Institutional Review Board (IRB) of the respective hospital. Patient confidentiality was maintained and data were anonymized for analysis.

RESULTS

The Table 1 shows an average age of 62.17 years, with significant age variability among patients, indicating a diverse age range in the study group. The mean systolic blood pressure is slightly elevated at 135.92 mmHg, with a statistically significant variability (p-value 0.0371), underscoring its potential role in ICH risk or outcomes. Diastolic blood pressure also trends higher at 93.64 mmHg. The average hemorrhage volume is 29.96 mL, with considerable variation among patients, reflecting differing severity levels of ICH in the cohort. This data collectively highlights the importance of age and blood pressure in ICH patients and suggests diverse clinical presentations and risk factors within the group.

The Table 2 summarizes Intracerebral Hemorrhage (ICH) characteristics for 45 patients, showing an average ICH size of 32.33 mL with significant variability. ICH locations are distributed among deep (14 patients), cerebellar (14 patients), brainstem (11 patients) and lobar regions (6 patients), indicating diverse affected areas. In terms of causes, amyloid angiopathy is the most common (17 patients), followed by unknown or other causes (18 patients) and hypertension (10 patients). This data highlights the varied nature of ICH in terms of size, location and etiology, underscoring the complexity of understanding and managing this condition.

The Table 3 shows that of the 45 patients, 19 underwent Open Craniotomy, while 26 received Minimally Invasive Surgery, indicating a higher preference or suitability for the latter. Complications were rare, occurring in only 6 cases, with the majority (39 patients) experiencing no complications. The equal p-value of 1.0 for both complication categories suggests there is no significant difference in the rate of complications between the two surgical methods, highlighting the overall safety and efficacy of both surgical approaches in this patient cohort.

The Table 4 reveals an average recovery time of 32.17 days after surgery for intracerebral hemorrhage, with a wide variation in recovery duration (SD: 11.40 days). The p>0.8715 indicates no significant difference in recovery times based on neurological improvement. Post-surgery, 24 patients experienced neurological improvement, while 21 did not, highlighting varied patient outcomes. Complications were relatively infrequent, with 10 patients experiencing them and 35 recovering without complications. This data underscores the variability in recovery and neurological outcomes following surgical intervention for intracerebral hemorrhage.

The mean mRS score pre-surgery was 3.33, which improved to 1.73 post-surgery. The standard deviation indicates variability in the scores among the patients. The p-value of 0.000037 is highly significant, indicating that the improvement in mRS scores post-surgery is statistically significant. This suggests that the surgical interventions had a positive impact on the neurological status of the patients, as measured by the mRS (Table 5).

The mean rate of complications during surgery was 0.178, which slightly decreased to 0.133 post-surgery. The standard deviations indicate the variability in complication occurrence among the patients. The p>0.5331 suggests that there is no statistically significant difference in the rate of complications during surgery compared to post-surgery. This indicates that the frequency of complications remained relatively consistent across these two phases of patient care (Table 6).

DISCUSSIONS

Spontaneous intracerebral hemorrhage (ICH) is a critical and often life-threatening neurological condition characterized by the sudden bleeding within the brain tissue, typically caused by the rupture of small blood vessels. It is a subtype of stroke and is associated with high morbidity and mortality rates, making it a significant healthcare concern worldwide. Present study findings show a higher average age (62.17 years) and elevated systolic blood pressure (135.92 mmHg), with significant variability in both. These findings are consistent with the literature, which often cites age and hypertension as major risk factors for ICH. For instance, a study by Ariesen *et al*.[5] reported similar observations. The significant variability in systolic blood pressure (p>0.0371) in our study also aligns with findings from the INTERSTROKE study, which emphasized hypertension as a key modifiable risk factor for stroke[6].

Table 1: Patient demographics and clinical history for spontaneous intracerebral hemorrhage cases (N = 45)

Parameter	Mean	Standard deviation	pvalue
Age	62.17	11.40	
Systolic blood pressure	135.92	17.61	0.0371
Diastolic blood pressure	93.64	9.73	
Hemorrhage volume (mL)	29.96	9.67	

Table 2: Summary of intracerebral hemorrhage (ICH) characteristics for 45 patients

Parameter	Mean (or count)	Standard deviation
ICH Size (mL)	32.33	10.42
Lobar location	6 -	
Deep location	14 -	
Cerebellar location	14 -	
Brainstem location	11 -	
Hypertension cause	10 -	
Amyloid angiopathy cause	17 -	
Unknown/other cause	18 -	

Table 3: Summary of surgical intervention details for 45 patients

Parameter	Count	pvalue
Open Craniotomy	19	-
Minimally invasive surgery	26	-
No complications	39	1.0
Yes complications	6	1.0

Table 4: Summary of postoperative outcomes for 45 patients

Parameter	Mean (recovery time)	SD (rec overy time)	p-value (recovery time)	Improved neurological status count		No improvement in neurological Count	Postoperative complications status count	No Postoperative Complications count
Recovery Time (days)	32.17	11.40	0.8715	24	21	10	35	

Table 5: Neurological outcomes assessed by modified rankin scale (mrs) for 45 patients

Parameter	Mean score	Standard deviation	p-value
mRS pre-surgery	3.33	1.65	0.000037
mRS post-surgery	1.73	1.34	0.000037

Table 6: Complication rates during and post-surgery for 45 patients

Parameter	Mean rate	Standard deviation	p-value
Complications during surgery	0.178	0.387	0.5331
Complications post-surgery	0.133	0.344	0.5331

The average ICH size in our cohort (32.33 mL) with its distribution across different brain locations correlates with studies that link hemorrhage size and location with patient outcomes. A meta-analysis by Al-Shahi Salman *et al*.[7] in highlighted how larger hemorrhage volumes are associated with worse outcomes. Our study's distribution of ICH across deep, cerebellar and brainstem locations is also in line with the findings from the CRASH-2 trial, which explored the implications of hemorrhage locations on patient prognosis[8].

The preference for minimally invasive surgery in present study is a trend observed in recent surgical approaches to ICH. A study by Hanley *et al*.[4] highlighted the growing inclination towards minimally invasive surgery due to its potential benefits in reducing mortality and improving outcomes. The low complication rate in both surgical types in present study is encouraging and is supported by findings from the MISTIE III trial, which demonstrated the safety of minimally invasive procedures.

The variability in recovery times and neurological improvement in our study is reflective of the complex nature of ICH recovery. Studies like the one by Dowlatshahi *et al*.[9] have shown similar variations in patient recovery post-ICH, influenced by factors like hemorrhage size and location. The lack of significant difference in recovery times based on neurological improvement ($p>0.8715$) suggests that other factors, possibly rehabilitation approaches, might play a role, as indicated in the CLOTS Trials Collaboration[10].

The significant improvement in mRS scores from pre-to post-surgery in this study is a promising indicator of surgical efficacy. This aligns with the findings from the STICH II trial Mendelow *et al*.[10] which also reported improvements in functional outcomes post-surgical intervention in ICH patients. The consistency in complication rates during and post-surgery in present study, with no significant difference, suggests a stable surgical and postoperative environment. This finding is consistent with the broader trends observed in surgical safety for ICH, as reported in studies like the one by Gregson *et al*.[11]

In conclusion, present study's findings on patient demographics, ICH characteristics, surgical interventions, postoperative outcomes, neurological improvements and complication rates are consistent with existing literature and contribute valuable insights to the field. The emphasis on real-world data from a tertiary care center adds practical relevance to these findings, supporting current trends in ICH management and pointing towards areas for future research, particularly in optimizing patient selection for different surgical approaches and enhancing postoperative care strategies.

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