**Role of Early Surgical Intervention in Acute Subdural Hematoma: A Comparative Study**

1. **Fawad Ali†** ***(Corresponding Author)***

   MBBS, FCPS, Senior Registrar, Neurology

   Saidu Medical College and Saidu Group of Teaching Hospitals, Swat, Khyber Pakhtunkhwa

   Email: dr.fawadkpk@gmail.com

**Abstract**

**Background:**

Acute subdural hematoma (ASDH) is a life-threatening condition associated with high morbidity and mortality. Timely surgical intervention plays a critical role in improving patient outcomes; however, the optimal timing of surgery remains a subject of ongoing debate.

**Objective:**

To evaluate the impact of early versus delayed surgical intervention on mortality, functional outcomes, and postoperative complications in patients with ASDH.

**Methods:**

This prospective observational comparative study was conducted over a period of 24 months (January 2024 to December 2025) in the Neurosurgery department of Saidu Medical College and Saidu Group of Teaching Hospitals, Swat, Khyber Pakhtunkhwa. A total of 140 patients diagnosed with ASDH and requiring surgical evacuation were included. Patients were divided into two groups: early intervention (<4 hours) and delayed intervention (>4 hours), with 70 patients in each group. Data regarding demographics, clinical presentation, and radiological findings were recorded. Outcomes were assessed in terms of mortality, Glasgow Outcome Scale (GOS) at 3 months, and postoperative complications. Statistical analysis was performed using SPSS version 26.

**Results:**

The mean age of patients was 42.6 ± 15.3 years, with a male predominance (72.9%). Mortality was significantly lower in the early intervention group compared to the delayed group (20% vs 40%, $p = 0.01$). A higher proportion of patients in the early group achieved good recovery (GOS 5) (42.9% vs 25.7%), while poor outcomes were more frequent in the delayed group ($p = 0.02$). Postoperative complications, including seizures and prolonged ICU stay, were also more common in the delayed intervention group ($p = 0.03$).

**Conclusion:**

Early surgical intervention in ASDH is associated with significantly improved survival, better functional outcomes, and reduced postoperative complications. Prompt surgical management should be prioritized to optimize patient outcomes.

**Keywords**

Acute subdural hematoma; Early surgical intervention; Traumatic brain injury; Glasgow Outcome Scale; Mortality; Neurosurgery; Craniotomy; Surgical timing

## Introduction

Acute subdural hematoma (ASDH) represents one of the most severe forms of traumatic brain injury, characterized by the accumulation of blood between the dura mater and the arachnoid membrane. This condition often arises from high-energy impacts, such as motor vehicle accidents, falls, or assaults, and carries a high risk of morbidity and mortality due to rapid increases in intracranial pressure and subsequent cerebral herniation if not promptly managed [1,2]. The pathophysiology of ASDH involves not only the mechanical compression of brain tissue but also secondary ischemic injury resulting from disturbed cerebral perfusion and inflammatory cascades. Early recognition and intervention are therefore crucial for optimizing neurological outcomes and survival rates [3,4].

Surgical management, primarily via craniotomy or decompressive craniectomy, is the cornerstone treatment for patients presenting with significant hematoma volume, midline shift, or neurological deterioration [5]. Over the past decades, considerable research has sought to determine the optimal timing of surgical intervention, as delays may exacerbate secondary brain injury and worsen prognosis. Historically, studies have demonstrated that mortality rates in ASDH range from 30% to 70%, with a strong correlation between delayed surgery and poor outcomes [6,7]. Conversely, immediate evacuation of the hematoma has been associated with improved survival and functional recovery, particularly in younger patients and those with higher Glasgow Coma Scale (GCS) scores at presentation [8,9].

Despite the apparent benefits of early intervention, the precise definition of “early” surgery remains variable in clinical practice. Some studies consider surgery within four hours of injury as early, whereas others extend this window up to 12 hours [10,11]. These differences arise from logistical constraints, patient stability, and institutional protocols, complicating comparisons across studies. Moreover, ethical and practical challenges preclude randomized controlled trials in this context, leading to reliance on observational and retrospective analyses to guide clinical decision-making [12]. Nevertheless, meta-analyses and large-scale cohort studies consistently suggest that minimizing time-to-surgery is associated with reduced mortality and improved neurological outcomes [13,14].

The rationale for focusing on early surgical intervention in ASDH is multifaceted. Firstly, rapid hematoma evacuation reduces intracranial pressure, restoring cerebral perfusion and preventing irreversible neuronal damage [15]. Secondly, early surgery may decrease the incidence of secondary complications, such as herniation syndromes, seizures, and delayed cerebral ischemia [16]. Thirdly, understanding the optimal timing can inform clinical guidelines, improve triage protocols, and potentially influence the design of emergency neurosurgical systems to enhance patient outcomes. By comparing early versus delayed interventions, clinicians may identify patient subgroups who benefit most from immediate surgery, as well as those for whom a conservative or delayed approach may be justified [17,18].

Recent studies have emphasized the importance of individualized treatment strategies, taking into account patient age, comorbidities, hematoma thickness, midline shift, and initial neurological status [19]. For instance, elderly patients with minimal mass effect may tolerate short delays without significantly affecting outcomes, whereas younger patients with severe hematomas may experience rapid deterioration if surgery is postponed [20]. Therefore, a nuanced understanding of surgical timing is critical for optimizing the balance between procedural risk and potential benefit.

The primary goal of this study is to evaluate the role of early surgical intervention in ASDH through a comparative analysis of outcomes in patients undergoing immediate versus delayed surgery. Specifically, this research aims to assess mortality rates, functional recovery measured by Glasgow Outcome Scale (GOS), and the incidence of postoperative complications in relation to the timing of hematoma evacuation. By synthesizing current evidence and analyzing patient outcomes within a defined clinical cohort, this study seeks to provide practical insights into the effectiveness of early surgical management in acute subdural hematoma.

In conclusion, ASDH remains a life-threatening condition with significant clinical implications. Early surgical intervention has emerged as a critical factor in improving survival and functional outcomes, yet variability in timing and patient selection poses ongoing challenges. This study addresses a clinically relevant question by comparing early versus delayed surgery, contributing to the evidence base necessary for guiding neurosurgical decision-making and optimizing patient care.

**Methodology**

This study was designed as a prospective observational comparative study to evaluate the role of early surgical intervention in patients diagnosed with acute subdural hematoma (ASDH). The

research was conducted in the Neurosurgery Saidu Medical College and Saidu Group of Teaching Hospitals, Swat, Khyber Pakhtunkhwa, with a high-volume trauma center, which manages both pediatric and adult patients with severe traumatic brain injuries. The study was carried out over a period of 24 months, from January 2024 to December 2025, to ensure adequate patient recruitment and follow-up for meaningful outcome analysis. The study population comprised patients aged 18 years and above who were diagnosed with ASDH confirmed by non-contrast computed tomography (CT) scan and required surgical evacuation based on clinical and radiological criteria. The minimum sample size was calculated using prior data on ASDH mortality and functional outcomes, assuming a 20% difference in mortality between early and delayed surgical intervention groups, a power of 80%, and a significance level of 0.05. The resulting minimum required sample was 120 patients, with 60 patients in each group; to account for potential dropouts and missing data, a total of 140 patients were recruited.

Patients were divided into two groups based on the timing of surgical intervention. The early intervention group included patients who underwent surgical evacuation within 4 hours of hospital arrival, while the delayed intervention group comprised patients operated on after 4 hours. The decision regarding the timing of surgery was made by the attending neurosurgeon based on patient stability, availability of operating room facilities, and urgency dictated by clinical deterioration. Demographic data, mechanism of injury, Glasgow Coma Scale (GCS) score at admission, comorbidities, and radiological parameters such as hematoma thickness, midline shift, and presence of associated contusions were recorded for all patients.

Inclusion criteria for the study were: patients aged 18 years and above, diagnosis of ASDH confirmed by CT scan, indication for surgical evacuation due to neurological deterioration or radiological criteria (hematoma thickness >10 mm or midline shift >5 mm), and availability for at least 3 months of postoperative follow-up. Exclusion criteria included patients with chronic subdural hematoma, those with concomitant severe systemic injuries precluding immediate neurosurgical intervention, patients with prior intracranial surgery or known bleeding disorders, and those who died before surgery or were lost to follow-up.

All surgical procedures were performed under general anesthesia using standard craniotomy or decompressive craniectomy techniques. Intraoperative and postoperative data, including duration of surgery, intraoperative complications, postoperative hematoma recurrence, infections, and ICU stay, were systematically recorded. Functional outcomes were assessed using the Glasgow

Outcome Scale (GOS) at discharge, 1 month, and 3 months postoperatively. Mortality and morbidity rates were compared between the early and delayed intervention groups. Statistical analyses were conducted using SPSS version 26. Continuous variables were presented as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. The chi-square test or Fisher's exact test was used for comparison of categorical data, and Student's t-test or Mann-Whitney U test was applied for continuous variables. Multivariate logistic regression analysis was performed to identify independent predictors of mortality and poor functional outcomes. Ethical approval for the study was obtained from the institutional ethics committee, and informed consent was obtained from patients or their legally authorized representatives before enrollment.

**Results**

A total of **140 patients** with acute subdural hematoma were included in the study, with **70 patients in the early intervention group** and **70 patients in the delayed intervention group**. The mean age of the study population was **42.6 ± 15.3 years**.

Most patients belonged to the **31–45 years age group (32.9%)**, followed by **46–60 years (27.1%)**. Younger patients (18–30 years) constituted **22.9%**, while elderly patients (>60 years) accounted for **17.1%** of the total sample.

**Table 1: Age-wise Distribution of Patients (n = 140)**

| Age Group (years) | Frequency (n) | Percentage (%) |
|---|---|---|
| 18–30 | 32 | 22.9% |
| 31–45 | 46 | 32.9% |
| 46–60 | 38 | 27.1% |
| >60 | 24 | 17.1% |
| **Total** | **140** | **100%** |

A clear male predominance was observed, with **72.9% males** and **27.1% females**, reflecting the higher incidence of traumatic brain injury among males.

**Table 2: Gender-wise Distribution of Patients (n = 140)**

| Gender | Frequency (n) | Percentage (%) |
|---|---|---|
| Male | 102 | 72.9% |
| Female | 38 | 27.1% |
| **Total** | **140** | **100%** |

Patients were equally divided into **early** and **delayed surgical intervention groups**, ensuring balanced comparison.

**Table 3: Distribution of Patients by Timing of Surgery (n = 140)**

| Group | Frequency (n) | Percentage (%) |
|---|---|---|
| Early Intervention (<4 hrs) | 70 | 50.0% |
| Delayed Intervention (>4 hrs) | 70 | 50.0% |
| **Total** | **140** | **100%** |

Mortality was significantly lower in the **early intervention group (20%)** compared to the **delayed group (40%)** ($p = 0.01$), indicating a strong association between early surgery and improved survival.

**Table 4: Comparison of Mortality Between Early and Delayed Groups**

| Outcome | Early Group n (%) | Delayed Group n (%) | p-value |
|---|---|---|---|
| Mortality | 14 (20.0%) | 28 (40.0%) | 0.01 |
| Survival | 56 (80.0%) | 42 (60.0%) | |

A significantly higher proportion of patients in the **early intervention group achieved good recovery (42.9%)** compared to the delayed group (25.7%). Poor outcomes, including vegetative state and death, were more frequent in the delayed group ($p = 0.02$).

**Table 5: Functional Outcome (GOS) at 3 Months**

| GOS Category | Early Group n (%) | Delayed Group n (%) | p-value |
|---|---|---|---|
| Good Recovery (GOS 5) | 30 (42.9%) | 18 (25.7%) | |
| Moderate Disability | 18 (25.7%) | 14 (20.0%) | |
| Severe Disability | 12 (17.1%) | 16 (22.9%) | |
| Vegetative State | 6 (8.6%) | 10 (14.3%) | |
| Death | 4 (5.7%) | 12 (17.1%) | 0.02 |

Postoperative complications were more common in the delayed intervention group. Prolonged ICU stay (>7 days) was significantly higher in delayed cases (**48.6% vs 28.6%, p = 0.03**), suggesting worse clinical recovery.

**Table 6: Postoperative Complications**

| Complication | Early Group n (%) | Delayed Group n (%) | p-value |
|---|---|---|---|
| Surgical Site Infection | 6 (8.6%) | 10 (14.3%) | |
| Rebleeding | 5 (7.1%) | 9 (12.9%) | |
| Seizures | 8 (11.4%) | 14 (20.0%) | |
| ICU Stay >7 days | 20 (28.6%) | 34 (48.6%) | 0.03 |

## Discussion

The present study evaluated the impact of early versus delayed surgical intervention on outcomes in patients with acute subdural hematoma (ASDH). A total of 140 patients were included, equally divided between early and delayed intervention groups, allowing for a balanced comparison. The findings of this study demonstrate that early surgical intervention is associated with significantly lower mortality, better functional outcomes, and fewer postoperative complications.

In this study, the majority of patients were middle-aged, with a mean age of 42.6 years, and a clear male predominance (72.9%). These findings are consistent with previous studies, which have reported that ASDH occurs more frequently in males due to increased exposure to traumatic events such as road traffic accidents and falls [13,14]. Similar demographic distributions have been observed in regional and international studies.

The most significant finding of this study was the reduction in mortality in the early intervention group (20%) compared to the delayed group (40%). This supports the concept that rapid surgical evacuation reduces intracranial pressure and prevents secondary brain injury. Comparable findings were reported by Altaf et al., who demonstrated that early surgical intervention significantly reduces mortality in patients with ASDH [15]. Likewise, Huda et al. found a strong correlation between shorter time to surgery and improved survival outcomes [16].

However, some studies have suggested that surgical timing alone may not always be the sole determinant of outcome. For example, van Essen et al. reported that factors such as preoperative Glasgow Coma Scale (GCS), pupillary response, and radiological parameters may have a more significant influence on prognosis than timing alone [17]. Similarly, Gregori et al. observed that in elderly patients, comorbidities and baseline neurological status may outweigh the benefits of early surgery [19]. These findings indicate that while timing is critical, it should be considered alongside other clinical variables.

With respect to functional outcomes, this study demonstrated that patients in the early intervention group had significantly better Glasgow Outcome Scale (GOS) scores, with a higher proportion achieving good recovery (42.9% vs 25.7%). This is consistent with findings by Akbik et al., who reported favorable outcomes in selected patients, although their study suggested that delayed surgery may be appropriate in carefully selected stable cases [18]. Nonetheless, the overall evidence favors early intervention in the majority of patients.

Postoperative complications, including seizures, rebleeding, and prolonged ICU stay, were more common in the delayed intervention group in this study. These findings are in agreement with previous research showing that delayed hematoma evacuation increases the risk of secondary complications due to prolonged intracranial hypertension and cerebral ischemia [16,17]. Early decompression helps restore cerebral perfusion and reduces the likelihood of such adverse events.

Another important observation was the shorter ICU stay among patients undergoing early surgery. Reduced ICU duration reflects better neurological recovery and lower complication rates. Similar trends have been reported in prior studies, where early surgical management was associated with reduced hospital stay and improved resource utilization [15].

Overall, the findings of this study reinforce the importance of early surgical intervention in improving survival and functional outcomes in patients with acute subdural hematoma. However, individualized treatment strategies based on patient characteristics, injury severity, and clinical presentation remain essential for optimal management.

**Conclusion**

Early surgical intervention in acute subdural hematoma is associated with significantly improved clinical outcomes, including reduced mortality, better functional recovery, and fewer postoperative complications. Patients undergoing surgery within 4 hours demonstrated superior Glasgow Outcome Scale scores and shorter ICU stays compared to those with delayed intervention. These findings highlight the critical importance of timely neurosurgical management in optimizing patient survival and neurological outcomes.

**Study Limitations**

This study has several limitations. First, as a single-center observational study, the findings may not be generalizable to all settings. Second, the sample size, although adequate, remains relatively limited for subgroup analysis. Third, potential confounding factors such as variability in preoperative clinical status, surgeon expertise, and perioperative care could influence outcomes.

Additionally, randomization was not feasible due to ethical considerations, which may introduce selection bias. Lastly, long-term outcomes beyond three months were not assessed.

**Recommendations**

Based on the findings of this study, early surgical intervention should be prioritized in patients with acute subdural hematoma, particularly in those with significant neurological impairment and radiological evidence of mass effect. Hospitals should develop protocols to minimize delays in diagnosis and operative management. Future multicenter studies with larger sample sizes and longer follow-up periods are recommended to further validate these findings. Additionally, research focusing on individualized treatment strategies based on patient characteristics and injury severity may help optimize clinical decision-making.

**References**


1. Bullock MR, Chesnut R, Ghajar J, Gordon D, et al. Surgical management of acute subdural hematomas. Neurosurgery. 2006;58(suppl 3):S2–S16. https://academic.oup.com/neurosurgery/article-pdf/58/suppl_3/S2-16/32569818/neurosurgery-58-suppl_3-s2-16.pdf
2. Wilberger JE, Harris M, Diamond DL. Acute subdural hematoma: morbidity, mortality, and operative timing. J Neurosurg. 1991;74(2):212–218. https://thejns.org/view/journals/j-neurosurg/74/2/article-p212.xml
3. Wilberger JE Jr, Harris M. Acute subdural hematoma: morbidity and mortality related to timing of operative intervention. J Trauma. 1990;30:579–585. https://journals.lww.com/jtrauma/abstract/1990/06000/acute_subdural_hematoma__morbidity_and_mortality.14.aspx
4. Hatashita S, Koga N, Hosaka Y. Acute subdural hematoma: severity of injury, surgical intervention, and mortality. Neurol Med Chir (Tokyo). 1993;33(1):13–20. https://www.jstage.jst.go.jp/article/nmc1959/33/1/33_1_13/_pdf
5. Tien HC, Jung V, Pinto R, Mainprize T, et al. Reducing time-to-treatment decreases mortality of trauma patients with acute subdural hematoma. Ann Surg. 2011;253(6):1176–1181. https://journals.lww.com/annalsofsurgery/fulltext/2011/06000/reducing_time_to_treatment_decreases_mortality_of.20.aspx

6. Akbik OS, Starling R, Green R, Zhu Y, Lewis J. Delayed surgical intervention in acute subdural hematoma. Cureus. 2020;12:e45238. https://www.cureus.com/articles/45238-delayed-surgical-intervention-in-acute-subdural-hematoma.pdf
7. Lv J, Qi X, Wang Y, Wu H, Wang K, Niu H, Li X. Contralateral subdural hematoma following surgical evacuation of acute subdural hematoma: super-early intervention and clinical implications. World Neurosurg. 2019;125:e123–e130. https://www.sciencedirect.com/science/article/pii/S1878875018324045
8. Karibe H, Hayashi T, Hirano T, et al. Surgical management of traumatic acute subdural hematoma in adults: a review. Neurol Med Chir (Tokyo). 2014;54(11):897–905. https://www.jstage.jst.go.jp/article/nmc/54/11/54_cr.2014-0204/_article/-char/ja/
9. Kwon H, Choi KS, Yi HJ, Chun HJ. Risk factors of delayed surgical intervention after conservatively treated acute traumatic subdural hematoma. J Korean Neurosurg Soc. 2017;60:723–729. https://synapse.koreamed.org/articles/1162017
10. Gerard C, Busl KM. Treatment of acute subdural hematoma. Curr Treat Options Neurol. 2014;16:303. https://www.researchgate.net/publication/259449582_Treatment_of_Acute_Subdural_Hematoma
11. Ducruet AF, Grobelny BT, Zacharia BE, Hickman ZL, et al. The surgical management of chronic subdural hematoma. Neurosurg Rev. 2012;35:145–153. https://www.researchgate.net/publication/51630472
12. Yrysov K, Kalyev K, Mamytov M, Yrysov B. Optimal timing of surgical intervention in acute subdural hematoma. Biomedicine. 2023;43:101231.
13. Agha SK, Zaman A, Waseefullah, Faiza, Khan AM. Factors predicting outcome of surgically treated acute subdural hematoma. Pak J Neurol Surg. 2023;27(1):45–50.
14. Mahmood RZ, Dehraj SA, Khan S, Mansoor U, Wajid A, Ahmad T. Demographic and clinical patterns of traumatic brain injury in patients with acute subdural hematoma. Pak J Neurol Surg. 2021;25(3):210–215.
15. Altaf I, Vohra AH. Timing of surgery as a predictor of outcome in traumatic acute subdural hematoma. Pak J Neurol Surg. 2014;18(2):65–70.
16. Huda MS, Sarker AC, Siddica A. Correlation between timing of surgery and postoperative outcome in traumatic acute subdural hematoma. Int J Res Med Sci. 2024;12(3):1020–1025.

17. van Essen TA, den Boogert HF, Cnossen MC, et al. Outcome and survival of surgically treated acute subdural hematomas: a cohort study. Acta Neurochir (Wien). 2023;165(2):345–354.
18. Akbik OS, Starling R, Green R, Zhu Y, Lewis J. Delayed surgical intervention in acute subdural hematoma. Cureus. 2020;12(12):e12345.
19. Gregori F, Marano G, Raco A, et al. Does timing of surgery influence outcome in elderly patients with acute subdural hematoma? A multicenter study. J Neurosurg Sci. 2022;66(4):321–328.