ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCES

DEPARTMENT OF ANESTHESIA

SURVIVAL STATUS AND PREDICTORS OF MORTALITY IN ADULTS UNDERGOING CRANIOTOMY FOR TRAUMATIC BRAIN INJURY: A MULTI-CENTER RETROSPECTIVE COHORT STUDY, ADDIS ABABA, ETHIOPIA

PRINCIPAL INVESTIGATOR

SISAY DEDEFO……………. BSc in Anesthesia

A RESEARCH THESIS SUBMITTED TO ADDIS ABABA UNIVERSITY, COLLEGE OF HEALTH SCIENCES, DEPARTMENT OF ANESTHESIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (MSC) IN ANESTHESIA.

ADDIS ABABA, ETHIOPIA

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Full Title of Research	Survival status and Predictors of Mortality in Adults Undergoing Craniotomy for Traumatic Brain Injury: A Multi-center Retrospective Cohort Study Addis Ababa, Ethiopia
Duration Of Research	From March 1/2025-july 2025
Study Area	TASH AND ALERT
Total Cost of Research	**25,250.00**
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Declaration

This is to certify that the thesis prepared by Sisay Dedefo, entitled: “The Survival status and Predictors of Mortality in Adults Undergoing Craniotomy for Traumatic Brain Injury: A Multi-center Retrospective Cohort Study is my own original work and that it has not been submitted previously, in whole or part, for award of any degree at any institution and I declare that all source of information used in the study have been appropriately acknowledged and referenced

This thesis is submitted in partial fulfilment of requirements for the Degree of Masters of sciences in advanced clinical anesthesia complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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1. Contents

ABBREVATIONS/ACRONYMS

ACS NSQIP American College of Surgeons National Surgical Quality Improvement Program

AHR	Adjusted hazard ratio
ALERT	Africa Leprosy Rehabilitation and Training Center
APACHEII	Acute Physiology and Chronic Health Evaluation II
CHR	Crude hazard ratio
CI	Confidence interval
CRASH	Corticoid Randomisation After Significant Head In- jury (CRASH)
CSF	Cerebrospinal fluid
DBP	Diastolic blood pressure
DC	Decompressive craniectomy
GCS	Glasgow Coma Score
HIV/AIDS	Human immunodeficiency virus /Acquired immune deficiency syndrome
HCT	Haematocrit
IBL	Estimated blood loss
ICP	Intracranial pressure
ICU	Intensive care unit
IHT	Intracranial hypertension
LFT	Liver function test
LMIC	Low and middle-income countries
MV	Mechanical ventilator
NICU	Neonatal intensive care unit
OFT	Organ function test
RBS	Random blood sugar
RFT	Renal function test
RTA	Road traffic Accident
SBP	Systolic Blood pressure
TASH	Tikur Anbessa Specialized Hospital
TBI	Traumatic brain injury

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ACKNOWLEDGMENT

First and foremost, I want to thank God for the grace and support that made this proposal possible. I'm grateful to Addis Ababa University's College of Health Sciences and the Department of Anesthesia for allowing me to do this research project, approving it ethically, and providing financial support. I also want to sincerely thank my advisors, Ms Senait and Wubayehu, for their excellent advice and help.

Abstract

BACKGROUND: Traumatic brain injury (TBI) accounts for a significant number of morbidities and mortalities globally, especially in low resource settings. Craniotomy is performed to reduce intracranial pressure and treat complications. however, survival outcomes and their predictors remain poorly defined, especially in low-resource setting.

OBJECTIVE: This Study aimed to assess the Survival status and predictors of mortality on patient age greater than 18 years who underwent Craniotomy for Indication of Traumatic brain injury at Tikur Anbessa Specialized Hospital and ALERT hospital from 2019-2023 GC Ethiopia, Addis Ababa.

METHODS: A five years A retrospective cohort study was conducted with 121 TBI patients who underwent craniotomy. Data was gathered through medical record review and analysed using Kaplan–Meier survival analysis (survival analysis) and Cox proportional hazards models (Cox model). The log-rank test was used to compare survival distributions among subgroups of patients.

Results: The overall mortality rate was 22% with its 95% CI: 14.6% to 29.4%**),** with a time of 6 months. The most deaths (19 deaths) occurred during the first observation interval, with a hazard ratio of 0.17 at that interval. Advanced age (AHR = 6.20; 95% CI: 2.37-16.19; p = 0.001); severe TBI (AHR= 6.06; 95% CI: 1.94-18.96; p = 0.002); intra-operative hypotension (AHR= 8.47; 95% CI: 2.81-25.55; p=0.001); and post-operative mechanical ventilation (AHR = 4.71; 95% CI: 1.35-16.36; p = 0.015) were independent predictors of mortality.

Conclusion: The study showed a significant mortality burden amongst post-craniotomy TBI patients due to both non-modifiable risk factors (age, severity of injury) and modifiable risk factors (hypotension, ventilation). These findings emphasize the need for prompt surgical management, more precise intra-operative monitoring, and effective postoperative management. Therefore, all stakeholders (policymakers, health care service providers, and researchers) need to work together to improve publicly funded trauma care systems to foster improved survivorship resource.

1. INTRODUCTION

1.1. Background of study

Traumatic brain injury (TBI) is a non-hereditary brain injury caused by a physical impact. It may result in altered mental status or death, as well as permanent or temporary impairment of cognitive, physical, and psycho-social functions(1). It can cause various symptoms, including loss of consciousness, memory problems, neurological issues, skull fractures, and brain damage. TBI is a critical global health issue, with a concerning 39% mortality rate. It affects people of all ages and backgrounds, making it a pressing public health issue worldwide in 2020(2)(3) .

Based on their mechanism, the ensuing head injuries are divided into two categories: nonpenetrating TBI, sometimes called a blunt TBI or closed head injury, and penetrating or open TBI. Based on the Glasgow Coma Score (GCS), which has been used as an objective method for describing the degree of altered consciousness in acute medical and/or trauma patients, traumatic brain injury (TBI) is classified as mild, moderate, or severe(4).

The higher mortality rate of traumatic brain injury (TBI) in low and middle-income countries is attributed to several factors, including limited access to healthcare due to transportation and financial barriers, inadequate emergency response systems, and a weak healthcare infrastructure that hinders timely and effective treatment. These challenges often lead to delayed patient presentation and underreporting of TBI-related deaths(1).

Research suggests that several factors influence TBI mortality rates. Non-modifiable factors include age, male sex, severe initial injury severity, and the cause of the injury. In contrast, modifiable factors include hypoxia, hypotension, hyperthermia, hypo/hyperglycaemia, delayed or inadequate surgical intervention, and failure to adhere to treatment guidelines. Addressing these modifiable factors may improve survival outcomes for individuals with TBI(5).

Traumatic brain injury (TBI) involves two types of injury. The primary injury, resulting from the initial trauma, is typically unavoidable. However, the secondary injury, which often includes complications like increased pressure within the skull (intracranial hypertension), reduced blood flow to the brain (ischemia), or seizures, can potentially be prevented. Research has shown that post-traumatic intracranial hypertension not only increases the risk of death but is also a major cause of preventable deaths following TBI. In patients with severe TBI and persistent high ICP despite medical treatment, decompressive craniectomy was performed (3).

Decompressive craniectomy, a surgical procedure to relieve pressure within the skull, has been used for decades to treat intracranial hypertension and prevent brain herniation in severe traumatic brain injury. However, its effectiveness in improving outcomes remains uncertain. Despite numerous studies, the results are conflicting, leading to significant debate within the medical community. While intracranial pressure typically returns to normal levels within four weeks after trauma, decompressive craniectomy, by lowering this pressure, may potentially alter the disease course and reduce mortality during this critical period(3). But Some randomized controlled trials have shown that while decompressive craniectomy can effectively reduce intracranial pressure and potentially lower mortality rates in severe traumatic brain injury, it may also increase the number of surviving patients with severe disabilities or in a vegetative state(6).

Despite being an effective way to save the lives of patients who present with severe traumatic brain damage, decompressive craniectomy is not without consequences. It is a resource-intensive treatment that often necessitates long-term rehabilitation after the procedure. The nation's healthcare expenditure may eventually increase as a result. Moreover, those patients still have the risk of dying even after a craniotomy.

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1.2. Statement of the problem

Traumatic Brain Injury (TBI) is a significant global health problem, with an estimated 69 million cases occurring annually. In developing countries like Ethiopia, the burden of TBI is particularly high. Studies in Africa report mortality rates from head injuries ranging from 4.2% to 35%, and in Ethiopia, over 20% of head-injured patients succumb to their injuries during treatment. These alarming figures highlight the critical need for improved trauma care systems in resource-limited settings (5).

Head injuries represent a significant public health concern in England and Wales, with approximately 1.4 million individuals seeking hospital treatment annually. These injuries are the leading cause of death among individuals under 40 years of age. While the overall in-hospital mortality rate is relatively low at 1%, the high incidence of head injuries (332/100,000 inhabitants) underscores the substantial impact of these injuries on public health. Falls and traffic accidents are the primary causes of head injuries in this population(7)(8).

In Morocco, between 2004 and 2006, 450 individuals over the age of 20 with head trauma were treated, with an average age of 38 years. The outcome was favourable in 72.86% of patients, with a mortality rate of 25.55%(9) .The observed 2-week mortality was 67%, which was 24% higher than expected based on the CRASH core model(10).

At TASH, A retrospective study revealed that head injuries accounted for nearly 60% of deaths among trauma patients admitted to the surgical service between 2002 and 2006. Furthermore, a more recent review of mortality in the emergency centre indicated that 21.5% of all deaths occurring within 72 hours of presentation were attributed to head injuries(11).

A study conducted at the Addis Ababa Emergency Centre, Tikur Anbessa Specialized Hospital, revealed that among 204 head injury patients enrolled, 21 patients died (10.3%). Between October 2012 and May 2013, 9956 patients visited the emergency department, and 220 died from this Head injuries (21.5%) were the leading causes of death. Sub-Saharan African patients with severe TBI face a mortality rate of 19%(12).

In patients with severe traumatic brain injury (TBI) and persistently high intracranial pressure (ICP) that cannot be controlled through medical interventions, decompressive craniectomy (DC) may be performed. This surgical procedure involves removing a portion of the skull to relieve pressure on the brain and allow for expansion of brain tissue.(13) Although there have been advancements in anesthesia, critical care, and general support, the risk of death during surgery associated with decompressive craniectomy remains substantial and has not significantly decreased compared to other major surgical procedures.

Traumatic brain injury (TBI) mortality rates are influenced by a combination of modifiable and non-modifiable factors. While factors like age, gender, and initial injury severity (low GCS scores) are difficult to change, conditions like hypoxia, hypotension, and hyperthermia, as well as suboptimal medical management (delayed surgery, inadequate treatment adherence), represent potentially preventable contributors to mortality. Addressing these modifiable risk factors presents a significant opportunity to improve outcomes for individuals with TBI (4).

Traumatic Brain Injury (TBI) is a significant and growing health concern in Ethiopia, resulting from various causes including car accidents, falls, and violence. Severe TBI often requires surgical intervention, such as craniotomy. However, the effectiveness of craniotomy in improving outcomes for TBI patients in Ethiopia is not fully understood. Limited access to neurosurgical care, particularly in rural areas, leads to delays in treatment, which can significantly increase mortality rates and contribute to long-term disabilities among TBI survivors.

A critical barrier to improving outcomes for Traumatic Brain Injury (TBI) patients in Ethiopia is the lack of comprehensive data on survival rates and their influencing factors. This data gap hinders effective resource allocation, targeted treatment planning, and informed decision-making in patient care. Moreover, it has significant social and economic consequences, impacting individuals, families, and the healthcare system.

Underdeveloped countries face significant challenges in managing traumatic brain injuries (TBIs), particularly those requiring craniotomy. Limited healthcare infrastructure and resources, coupled with the high cost of this life-saving procedure, pose substantial barriers to effective treatment. The financial burden of craniotomy and subsequent rehabilitation can devastate families, hindering economic growth and exacerbating social and economic disparities.

While we are aware of the risk of death following craniotomy surgery, more research is needed to identify specific factors that may predict this risk. By investigating these factors and understanding their impact on patient outcomes, we can make more informed decisions about who should undergo this surgery and potentially improve overall patient survival rates.

Previous studies in Ethiopia have reported high mortality rates among Traumatic Brain Injury (TBI) patients, exceeding those of other emergency cases. Notably, mortality rates varied across locations and significant disparity in mortality was observed between patients who underwent neurosurgical interventions (craniotomy or burr hole placement) with a 4.44% mortality rate and those who did not (14.3%). However, these studies often employed a uniform set of predictive factors for both groups, neglecting crucial pre-trauma patient characteristics and potential surgical/anesthesia-related risk factors that may significantly influence outcomes for patients undergoing neurosurgical procedures(14).

Therefore, this study aims to determine survival status and predictors of mortality in patients age >18 years who underwent craniotomy for indication of Traumatic brain injury at TASH and ALERT from 2019-2023 GC Ethiopia, Addis Ababa.

1.3 Significance of the Study

This study offers vital insights into how adults in Addis Ababa's tertiary hospitals fare after undergoing craniotomy for traumatic brain injury (TBI), and what factors predict their survival. It examines connections between survival rates and crucial clinical indicators like Glasgow Coma Scale (GCS) scores, low blood pressure (hypotension), anesthesia type, events during surgery, and post-operative complications. By specifically focusing on craniotomy patients and excluding those who had burr hole procedures, this research addresses a significant gap in what's known about neurosurgery in Ethiopia.

This study's findings will be invaluable for neurosurgeons, anesthetists, and trauma teams, helping them effectively identify and prioritize high-risk patients undergoing craniotomy for traumatic brain injury. By recognizing crucial indicators like low Glasgow Coma Scale scores, intraoperative hypotension, and other perioperative complications, healthcare providers can implement targeted interventions and make timely clinical decisions. This proactive strategy promises to lead to improved patient monitoring, more efficient resource allocation in both the operating room and intensive care unit, and ultimately boost survival rates and recovery outcomes for severely injured patients.

This study's findings will be crucial for shaping national trauma care policies and guiding resource allocation decisions by Ethiopia's Ministry of Health and hospital administrators. By providing locally relevant data on survival rates and factors predicting death for TBI patients undergoing craniotomy, the study will highlight areas that need investment and policy support. This will empower healthcare leaders to prioritize funding, optimize trauma care infrastructure, and develop strategic plans that address the unique challenges of managing traumatic brain injuries within Ethiopia's healthcare system. Ultimately, these efforts will improve the overall quality and accessibility of trauma services nationwide.

This study will also play a crucial role in creating standardized clinical protocols and risk stratification tools tailored for TBI surgical cases. These tools are vital in places with limited resources, as they'll help clinicians make evidence-based decisions and ensure consistent, high-quality care for TBI patients undergoing craniotomy.

This study will be a vital reference for future clinical research and surveillance aimed at improving neurosurgical outcomes, especially in resource-limited settings like Ethiopia. By pinpointing crucial mortality predictors and survival trends in TBI patients undergoing craniotomy, it creates a foundational evidence base for other researchers and healthcare professionals to expand upon.

2. LITERATURE REVIEW

2.1. General Overview on the topic

Traumatic Brain Injury (TBI) is a major global health concern, leading to high rates of morbidity and mortality. Craniotomy, a key surgical intervention for severe TBI, aims to alleviate intracranial pressure and enhance survival outcomes. Despite advancements in surgical techniques and perioperative care, survival rates and long-term prognoses vary significantly. Identifying the factors that influence survival after craniotomy is critical for optimizing patient outcomes and guiding clinical decision-making. Existing research highlights various predictors, including demographic variables (e.g., age and sex), clinical indicators (such as Glasgow Coma Scale scores and pupillary reactivity), and imaging findings. However, the diversity of patient populations and treatment protocols presents challenges to the generalization of findings.

Recent studies emphasize the integration of advanced imaging technologies, biomarker assessments, and machine learning models to improve the prediction of survival outcomes. There is also growing interest in multidisciplinary strategies, including early rehabilitation and comprehensive intensive care, to enhance long-term recovery. Despite these advancements, research gaps remain, particularly regarding the interplay of clinical and socioeconomic factors and the lack of standardized data collection protocols. This review synthesizes current evidence on survival predictors in TBI patients undergoing craniotomy, addressing demographic, clinical, and procedural factors while highlighting areas for further investigation to inform future research and clinical practices.

2.2. Survival Time of patients who underwent craniotomy for indication of TBI

A retrospective study analysing data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) examined the outcomes of 1,634 adult patients who underwent TBI-related surgery between 2005 and 2017. This study, conducted in a high-income setting with robust surgical infrastructure, reported a 30-day mortality rate of 20.3% and assessed overall complications. Using statistical methods like logistic regression and chi-squared analysis, it identified significant predictors of mortality, confirming the model's accuracy. However, the findings of this study have limited relevance to low-resource environments like Ethiopia. In Ethiopia, where factors such as delayed medical intervention, limited critical care facilities, and differing perioperative procedures are common, mortality rates for TBI craniotomies are likely much higher. This underscores the critical need for localized data to understand the specific outcomes in such settings(4).

A retrospective cohort study from Zagazig University Hospital in Egypt sheds light on the grim reality for adult patients with severe traumatic brain injury (TBI) who undergo decompressive craniectomy. Of 104 patients with a Glasgow Coma Scale (GCS) score of 8 or less, an alarming 30.77% did not survive the post-operative period. This high mortality rate underscores the severe prognosis associated with TBI, even with surgical intervention, and is notably higher than the 15-25% mortality rates typically seen in high-income countries. The Egyptian data highlight the profound impact of healthcare system limitations, such as delayed interventions, insufficient intensive care capacity, and a lack of advanced monitoring, on patient outcomes. Given Ethiopia's similar resource constraints, it's highly probable that mortality rates for craniotomy patients with severe TBI will be comparable or even worse. This emphasizes the critical need for localized survival data to inform clinical practice and improve neurosurgical outcomes within the Ethiopian context (3).

A retrospective cross-sectional study conducted at Liaocheng People’s Hospital in Pakistan, involving 112 TBI patients who underwent decompressive craniectomy between 2017 and 2018, reported a concerning mortality rate of 45.5%. A significant portion of these deaths, 37%, occurred within the first 30 days post-surgery, pointing to a high early postoperative mortality. The severity of injuries in this patient group, evidenced by a low mean preoperative Glasgow Coma Scale (GCS) score of 5.24, likely contributed to this elevated death rate. This mortality burden is notably higher when compared to studies from Egypt (30.77%) and the United States (20.3%), suggesting the influence of factors prevalent in lower-resource settings such as limited resources, delays in surgical intervention, and inadequate postoperative care. These findings imply that, in contexts similar to Ethiopia, mortality rates following TBI surgery could be similarly high, thereby emphasizing the critical need for localized data to comprehend outcome patterns and guide life-saving interventions.(6).

A cross-sectional study conducted at Yaoundé Central Hospital in Cameroon assessed the postoperative outcomes of 100 consecutive traumatic brain injury (TBI) patients who underwent surgery within 72 hours of their injury. The study reported a postoperative mortality rate of 15%, which is lower than figures observed in other low- and middle-income countries. These findings underscore the potential for improved survival when prompt surgical care is accessible, a point particularly relevant for Ethiopia, which grapples with similar challenges in emergency response and critical care. Therefore, this study emphasizes both the crucial role of early intervention and the imperative for local survival data to bolster TBI care systems in comparable resource-limited environments (22).

A prospective study conducted at Kenyatta National Hospital in Kenya, analysing 87 adults severe TBI patients admitted to the ICU between April and September 2005, reported a strikingly high mortality rate of 54%. Underscoring the severe nature of their injuries compounded by the limitations of critical care often found in sub-Saharan African healthcare settings. These findings highlight the extreme vulnerability of severely injured TBI patients in resource-constrained environments and the urgent need for prompt and aggressive medical intervention. Given the similar healthcare system challenges prevalent in Ethiopia, it is likely that local outcomes for TBI craniotomy patients may mirror this high mortality rate. This reinforces the critical importance of generating country-specific survival data to inform clinical guidelines and improve the overall management and prognosis of TBI patients in Ethiopia(15).

A follow-up study from Hawassa University in Ethiopia looked at outcomes for 1,220 traumatic brain injury (TBI) patients, including those who had burr holes or other brain surgeries. The study found that patients who received surgery had a much lower death rate (4.44%) compared to those who didn't (14.3%). While the inclusion of less invasive burr hole procedures might have affected the overall surgery survival rates, the study clearly shows that getting neurosurgery quickly significantly improves a TBI patient's chance of survival. This underscores the urgent need for more surgical facilities and faster access to care for TBI patients in Ethiopia).(5)

A study at Addis Ababa Emergency Centre found that road traffic accidents were the leading cause of head injuries among 204 patients, accounting for 41% of cases. The overall mortality rate was 10.3%.).(14) A study at Addis Ababa Emergency Centre examined outcomes for 220 patients who died within 72 hours of admission between 2012 and 2013. Excluding those who died on arrival, the average age of death was 43.1 years and the overall mortality rate was 1.9%. Head injury and sepsis were the most common causes of death. TBI fatality rates varied across regions, with higher rates reported in Hawassa and Bahir Dar compared to Addis Ababa.(12)

Death rates following traumatic brain injury (TBI) surgery differ significantly globally, with high-income countries seeing around 20% mortality, while some low-resource nations like Kenya and Pakistan report over 50%. In Ethiopia itself, TBI mortality varies regionally and by study, from under 2% to over 14%, due to factors like injury severity, surgical intervention, and healthcare system capabilities. Differences in how studies are designed, such as whether less invasive burr hole procedures are included, also impact these reported figures. This broad inconsistency underscores the urgent need for specific, local research to accurately determine survival rates and predict mortality for Ethiopian TBI patients undergoing craniotomy. Such data are crucial for enhancing clinical care and informing health policies to prevent avoidable deaths.

2.3. Predictors of Mortality Among Patients who underwent craniotomy for indication of TBI.

A major analysis of 1,634 patients in a high-resource setting (ACS NSQIP database, 2005-2017) revealed several key preoperative predictors of 30-day mortality after TBI surgery: older age, race, pre-existing conditions like diabetes, hypertension, and congestive heart failure, recent smoking, prolonged coma (over 24 hours), emergency surgery, poor overall health before surgery, systemic sepsis, and needing large blood transfusions (over 4 units). While this highlights the complex factors influencing outcomes in well-equipped environments, these predictors may manifest differently in low-resource settings such as Ethiopia, where delays in care and limited monitoring during and after surgery could significantly alter their impact. This underscores the critical need for localized research in Ethiopia to understand context-specific predictors and improve TBI care(4).

A retrospective study from the Australian Department of Defence investigated how quickly craniectomy is performed after a traumatic brain injury (TBI) affects patient survival. The findings revealed a substantial decrease in deaths when the surgery was done within 5.33 hours of the injury. This strong link between early intervention and improved survival remained even after accounting for other influencing factors and potential biases, emphasizing the critical role of prompt surgical care in TBI cases. These results highlight the importance of minimizing delays in neurosurgical treatment, a challenge particularly relevant for low-resource settings like Ethiopia, where logistical obstacles often prolong the time until surgery can be performed(16).

A retrospective study at Liaocheng People's Hospital in China, examining 112 TBI patients who underwent decompressive craniectomy (2017-2018), reported Significant predictors of mortality included pupil abnormalities, time from injury to surgery, intraoperative blood loss, and postoperative Glasgow Coma Scale (GCS) score, with older age and postoperative hypernatremia independently linked to increased risk. These findings underscore that mortality in TBI surgery is influenced by a complex mix of patient factors before surgery and physiological issues during and after the operation, and emphasize the critical need for prompt surgical intervention and meticulous postoperative management. Such comprehensive care, however, presents considerable challenges in resource-limited environments like Ethiopia, suggesting that these insights from China are highly relevant to understanding and addressing TBI mortality in similar settings.(6).

A retrospective study conducted at the National Institute of Mental Health and Neurosciences in Bangalore, India, investigated factors influencing 6-month survival in 206 elderly traumatic brain injury (TBI) patients who underwent craniotomy. Through logistic regression analysis, the study identified pupillary reaction and motor score as significant predictors of survival. This emphasizes the critical role of early neurological assessment in forecasting long-term outcomes. These findings highlight the practical value of straightforward clinical indicators, which could prove especially beneficial in low-resource environments such as Ethiopia, where access to advanced monitoring technologies may be restricted(17).

A retrospective chart analysis of pediatric patients with traumatic brain injury (TBI) admitted to the neurotrauma intensive care unit (NICU) at Akash Super Speciality Hospital in New Delhi, India, was conducted. Among the 105 children hospitalized over a year, 14.3% experienced mortality. Multivariate analysis identified a Glasgow Coma Scale (GCS) score of 8 or lower after resuscitation upon admission and an extended NICU stay of more than 7 days as independent predictors of poor outcomes and mortality, respectively.(18).

A retrospective study conducted in Pakistan on pediatric patients undergoing decompressive craniectomy for traumatic brain injury revealed several factors linked to poorer outcomes. Specifically, lower Glasgow Coma Scale (GCS) scores at presentation, delays in seeking medical attention, performing decompressive craniectomy more than four hours after hospital admission, and significant intraoperative blood loss (exceeding 300 ml) were all significantly associated with a worse prognosis. These findings underscore the critical importance of timely intervention and effective surgical management in improving outcomes for pediatric TBI patients, challenges that are particularly acute and relevant in resource-limited settings like Ethiopia(19).

A prospective cohort study examining 30 cases of severe traumatic brain injury undergoing craniotomy at Sanjay Gandhi Memorial Hospital in India identified several significant predictors of mortality. These included advanced age (100% mortality in patients over 55), road traffic accidents as the primary cause of injury (61.11% of deaths), prolonged loss of consciousness (>6 hours), non-reactive pupils on admission, a low Glasgow Coma Scale (GCS) score (<8), intraoperative hypotension, postoperative GCS score ≤ 8 at 24 hours, and preoperative hyperglycaemia(20)

A retrospective cohort study at Zagazig University Hospital in Egypt examined outcomes for 104 patients with severe TBI (GCS ≤ 8) who underwent decompressive craniectomy. Logistic regression analysis identified GCS score 8. The overall mortality rate was 30.77%.(3)

A retrospective follow-up study at Hawassa University, analysing 1,220 traumatic brain injury (TBI) patients, utilized Cox proportional hazards regression to pinpoint independent predictors of mortality. The findings revealed that patients with moderate and severe TBI faced a significantly higher risk of death (severe TBI with an Adjusted Hazard Ratio (AHR) of 8.8, and moderate TBI with an AHR of 3.0, indicating a threefold to nearly ninefold increased risk). Additionally, patients aged over 65 years showed a 3.48 times increased hazard ratio for mortality, and the presence of hypotension elevated the risk by 1.72 times. These results strongly underscore the profound impact of injury severity, advanced age, and hemodynamic instability (like low blood pressure) on the survival of TBI patients, highlighting critical areas for targeted clinical management strategies within Ethiopian healthcare settings(5)

A retrospective cohort study at Felegehiwot Comprehensive Specialized Hospital analysed data from 338 patients aged 15 and older with traumatic brain injury. The study found a crude death rate of 25.53 per 1000 person-days of follow-up, with a median survival time of 44 days. Independent predictors of mortality included bilateral non-reactive pupils at admission (adjusted hazard ratio [AHR]: 2.00), an admission Glasgow Coma Scale score of 8 or lower (AHR: 0.31), and elevated diastolic blood pressure upon admission (AHR: 3.54)(1).

2.4. Summary

Studies on mortality and survival following craniotomy or decompressive craniectomy for traumatic brain injury (TBI) reveal considerable global variation, particularly within low-resource settings. Reported mortality rates range widely, from approximately 15% in Cameroon and parts of Ethiopia to over 50% in Kenya and Pakistan, reflecting differences in healthcare infrastructure, the timing of surgical intervention, and patient factors. Common predictors of mortality include advanced age, low Glasgow Coma Scale (GCS) scores, prolonged coma, hypotension, delayed surgical intervention, and perioperative complications such as blood loss and hypernatremia. Regional Ethiopian data from Hawassa University underscore the increased risk for older patients, those with moderate to severe TBI, and those experiencing intraoperative hypotension. Studies also emphasize that earlier surgical intervention—ideally within hours of injury—is critical to improving survival. Despite some local data, inconsistencies and gaps remain, particularly regarding comprehensive, multicentre Ethiopian cohorts and perioperative factors. This underscores the need for focused research to better understand survival patterns and predictors in the Ethiopian context to improve patient outcomes and guide policy.

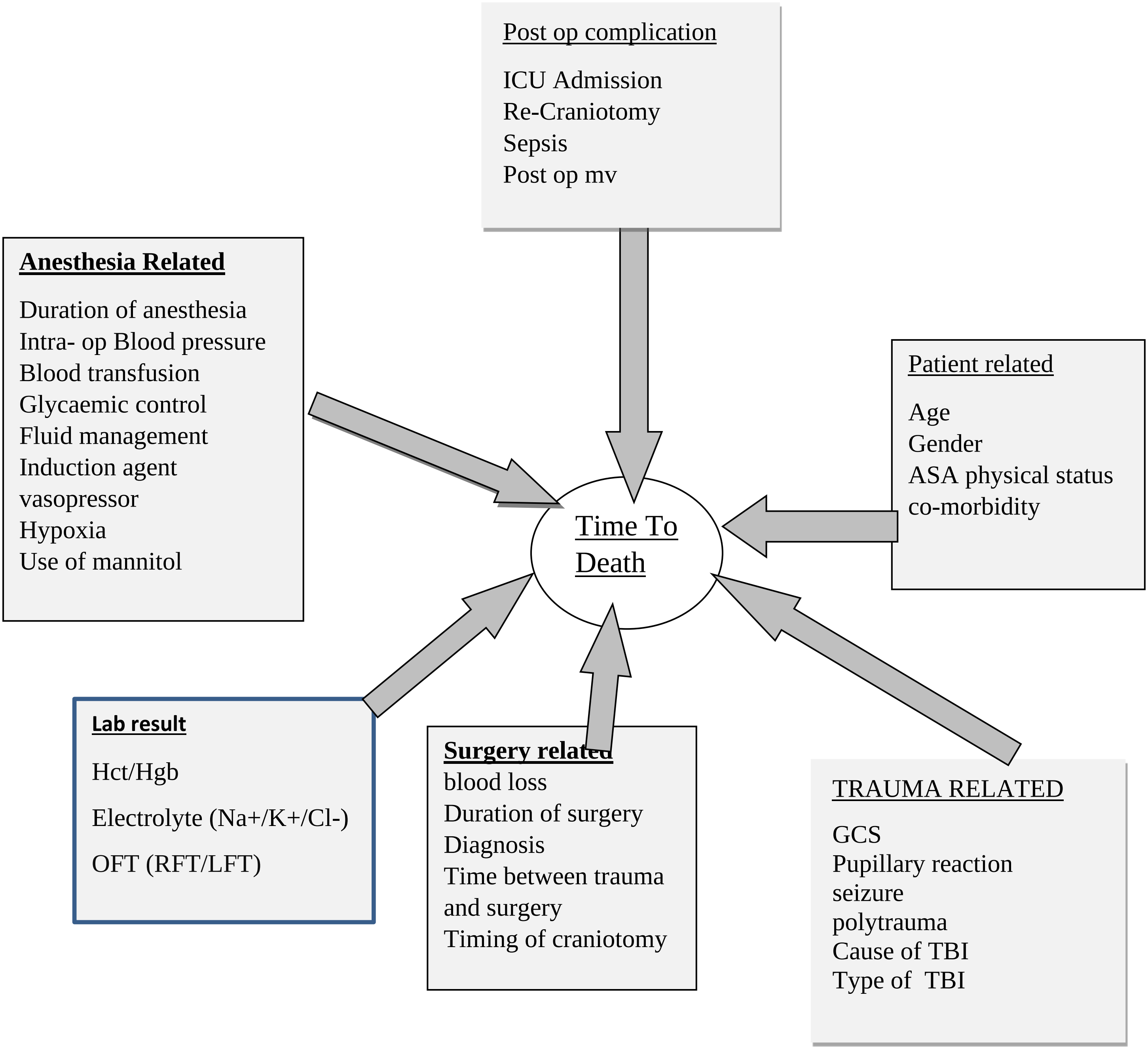

Figure 1:Conceptual framework of Predictors of Mortality Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023).

3. OBJECTIVE OF THE STUDY

3.1. General Objective

To determine Survival status and identify predictors of mortality in patients aged >18 years who underwent craniotomy for indication of Traumatic brain injury at TASH and ALERT from 2019-2023 GC Ethiopia, Addis Ababa.

3.2. Specific Objective

To determine the Survival status of patients over age 18 years who underwent craniotomy for indication of Traumatic brain injury at TASH and ALERT Hospital from 2019-2023 GC Ethiopia, Addis Ababa.

To Identify the predictors of mortality in patients who underwent craniotomy for indication of Traumatic brain injury TASH and ALERT hospital from 2019-2023 Ethiopia, Addis Ababa).

4. METHODOLOGY

4.1 Study Area and Period

This study was conducted in Addis Ababa, Ethiopia, at two key public healthcare institutions: Tikur Anbessa Specialized Hospital and ALERT Hospital. These hospitals were deliberately chosen from the city's 13 public hospitals because they handle a large volume of patients, making them highly relevant to the study's focus on traumatic brain injury (TBI) surgery outcomes. Tikur Anbessa is Ethiopia's largest referral and teaching hospital, handling a significant number and diversity of surgical cases, including trauma. ALERT Hospital is also a prominent institution, housing one of the capital's busiest traumas centres, equipped with emergency department beds, inpatient trauma ward beds, critical care beds, and operating rooms dedicated to trauma. Their high patient volumes and specialized services make them ideal settings for investigating the survival status and predictors of mortality among adults undergoing craniotomy for TBI.

Black Lion Specialized Hospital, also known as Tikur Anbessa Specialized Hospital, was founded in 1972 E.C. As the biggest specialized hospital in Ethiopia, it serves as the primary teaching facility for numerous academic fields preclinical and clinical training programs. Numerous medical specialists from different specialties work at the facility. There are roughly 17 operating rooms and 800 beds overall.

The ALERT hospital, originally a research centre for leprosy and tuberculosis, has grown into a comprehensive hospital serving the community. Founded in 1970, it now offers general medical services, conducts research, and trains medical professionals. The 530-bed teaching hospital includes departments for dermatology, ophthalmology, and surgery, as well as an orthopaedic workshop and a rehabilitation program. Notably, the trauma and emergency department handle around 7,500 cases per year.

Data collection took place between February and April 30, 2025, during which the medical records of patients who underwent craniotomies from January 1, 2019, to December 30, 2023, were reviewed for evidence of traumatic brain injury. Retrospective follow-up began at the time of craniotomy and **e**nded at the date of death, date of loss to follow-up, date of last contact, or a combination of these events.

4.2. Study Design

A retrospective cohort study was carried out at Tikur Anbessa Specialized Hospital and ALERT Hospital by examining the medical records of patients who underwent craniotomies for traumatic brain injury.

4.3. Source and Study Population

4.3.1. Source Population

All medical records of patients who underwent craniotomy for the indication of TBI at Tikur Anbessa Specialized Hospital and ALERT Hospital.

4.3.2. Study Population

The study included medical records of patients admitted to the surgical ward at Tikur Anbessa Specialized Hospital and ALERT Hospital who underwent craniotomy for TBI between 2019 and 2023, provided they met the specific criteria for inclusion and exclusion.

4.4 Inclusion and Exclusion Criteria

4.4.1. Inclusion Criteria:

All patients aged ≥18 years who underwent craniotomy for traumatic brain injury between 2019 and 2023 and who fulfilled the eligibility criteria were included in the study.

4.4.2. Exclusion Criteria

Craniotomy cases for traumatic brain injury with incomplete personal information—such as age, sex, date of first diagnosis, or type of treatment received—were excluded from the study. Patients with pre-existing terminal illnesses were also excluded.

4.5 Sample Size Determination

For the first objective, Sample size was determined using the equation for single population proportion

$$n = \frac{Z^2 P(1-P)}{d^2}$$

where:

n= sample size

p=0.45 Proportion of Operative mortality at 6-month follow-up was 45.5%, while 37 (33.0%) patients died within 30 days**.**(6)

(1-p) =0.55

d= margin of error 5%

Z= confidence interval 95%

$$n = \frac{Z^2 P(1-P)}{d^2} = \frac{1.96*0.45*0.55}{0.05^2} = 176$$

Final sample size=176+10% =193

For the second objective of identifying predictors, the sample size was determined using the Cox Proportional Hazards Model. This statistical method was chosen based on its suitability for analysing survival data. Age, Glasgow Coma Scale (GCS), hypotension, and bilateral non-reactive pupils were selected as the primary independent predictor variables, informed by a previous study conducted in Ethiopia.(1)(5) The sample size was calculated by using Stata/SE Version 14.0 with the equation below.

$$N1 = \frac{\left[Z_{\alpha/2} + Z_{\beta}\right]^2}{(\ln(HR)^2)\cdot p\cdot(1-p)}$$

Z α/2: is taking CI 95%

Zβ: 80% power

AHR =Logarithm Hazard ratio of independent predictor factor

p = overall event rate in the study population

The risk of death among patients above 65 years old was 3.48 times (AHR: 3.49; 95% CI;1.63–7.48) higher than those under 18 years. hypotensive patients was 1.72 (AHR:1.72[95% CI; 1.11–2.63]) times higher, hypoglycaemic patients was 1.94 (AHR: 1.94; 95% CI; 1.34–2.81) times higher.(5)

Glasgow coma scale score ≤ 8 (adjusted hazard ratio (AHR): 4.85; 95% confidence interval (CI): 1.73–13.62), bilateral non-reactive pupils at admission (AHR: 2.00 (95% CI: 1.10–3.71), elevated diastolic blood pressure at admission (AHR: 3.54; 95% CI: 1.33–9.43).(1)

Table 1:Sample size calculation for predictors factor Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023).

Independent covariance	AHR	Event rate	Sample size	After adding 10%
Age	3.49	45.5%	47	52

GCS <8	4.85	45.5%	30	33
Hypotension	1.72	45.5%	237	261
Non-reactive pupils	2.00	45.5%	146	161

Among the independent variables analysed, hypotension was found to have the strongest association with the outcome of interest, leading to the largest required sample size. This suggests that hypotension is a significant factor influencing the outcome. (5) The sample size calculated using the Cox Proportional Hazards Model was larger than that obtained using the single population proportion formula. Consequently, the largest sample size of 261 was be adopted as the final sample size for the study. This decision ensures adequate statistical power to detect significant relationships between the variables of interest

While the initial plan was to obtain a larger sample with a sampling strategy, the total population available at the time of study was less than the estimated sample size. Therefore, patients who met the inclusion criteria for the study were all included by following a consecutive sampling strategy

4.6 Sampling technique and Procedure

To identify suitable participants for the study, researchers reviewed the medical records of all patients who underwent craniotomy at Tikur Anbessa Specialized Hospital (TASH) and ALERT Hospital between 2019 and 2023. From this pool, only records of patients whose craniotomy was specifically for traumatic brain injury (TBI) were included. A consecutive sampling approach was employed, meaning every eligible medical record found during the study period was included, rather than a random selection. This method was chosen due to the limited number of relevant cases available. Each selected medical record was then followed retrospectively for a period ranging from a minimum of 30 days to a maximum of 6 months after the craniotomy to assess the patient's survival status and identify factors predicting mortality.

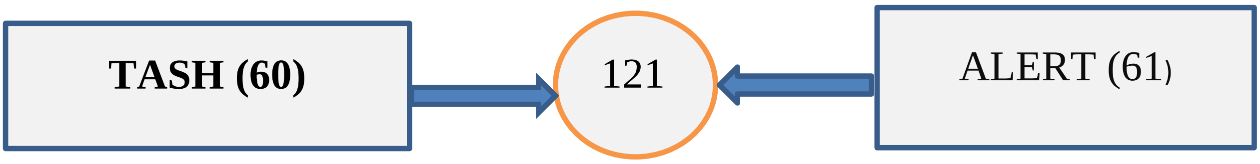

Figure 2:sample size distribution for selected study area Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023).

While the initial plan was to obtain a larger sample with a sampling strategy, the total population available at the time of study was less than we estimated. Therefore, patients who met the inclusion criteria for the study were all included by following a consecutive sampling strategy.

4.7 Variables

4.7.1 Dependent Variables

Survival status after Craniotomy

4.7.2 Independent Variables

- **Patient related** (Gender, Age, ASA physical status and co-morbidity),
- **Anesthesia related** (intraoperative hypotension and hypertensive, Blood transfusion, Intra op glucose level, duration of anesthesia, Hypoxia, Fluid management, Induction agent Body temperature and vasopressor)
- **Surgery related** (Blood loss, Duration of surgery, Diagnosis and Time between trauma and surgery, Time between trauma and surgery and Timing of craniotomy
- **Post op complication** (ICU Admission Re-Craniotomy, Sepsis and post op mechanical ventilation)
- **Trauma related** (GCS, Pupillary reaction, Delay presentation, seizure and polytrauma, Diagnosis, Time between trauma and surgery, Cause of TBI)
- **Laboratory result (**Hct/Hgb/Electrolyte (Na+/K+/Cl-)/OFT(RFT/LFT**)**

4.8 Operational Definitions

Operative mortality: is defined as any death occurring during hospitalization or within 30 days post-discharge after surgery.

Censored: Patients who were lost to follow-up before developing the event, have incomplete information on the date of death, who died due to other known causes unrelated to TBI or Craniotomy, who do not have registered phone numbers and their current status is unknown, were censored to the last follow-up date. For patients who survived, data was censored as of February 30, 2024, if their last follow-up was beyond that date.

Event: Death of patients after Craniotomy

The survival time was calculated from the craniotomy date, which occurred between January 1, 2019, and December 30, 2023. The follow-up period concluded on the last follow-up date, either the date of the patient's death or February 30, 2025, if the patient was censored).

Mortality (Outcome Variable): death during follow-up period

Follow up time period: The time from the beginning of the study period to an event, end of the study, or loss of contact or withdrawal from the study.

Survival time: in this study was calculated by subtracting the craniotomy date from the last date of patient contact.

Survival status: The status of the patients' survival to the outcome (death) or censored.

Time to death: Time of Craniotomy to death.

Incomplete data: When one of independent variables was not registered.

postoperative mortality: defined as death within 30 days of Craniotomy or death during the hospitalization in which the primary surgical procedure was performed.

In-hospital deaths: that occurred in more than 30 days after Craniotomy

GCS: A clinical assessment tool used to evaluate the level of consciousness in patients with head injuries score from(3-15) and determined based on three components: eyes (four = opening spontaneously, three = opening to verbal command, two = opening to pain, and one = no eye opening), verbal (five = oriented, four = disoriented, three = inappropriate words, two = incomprehensible sounds, and one = no verbal response), and motor (six = obeys, five = localizes pain, four = withdrawal, three = abnormal flexion, two = abnormal extension, and one = no motor response(21).

Hypotension: Blood pressure is measured in millimetres of mercury (mm Hg), and generally considered low when below 90/60 mm Hg.

Hypertension: high blood pressure) is when the pressure in your blood vessels is too high (140/90 mmHg or higher.

Length of Hospital Stay: is a clinical metric that measures the time elapsed between a patient's hospital admittance and discharge.

Length of ICU Stay: Is the time between when a patient is admitted to the ICU and when they are discharged with improvement or death.

Comorbidities: were identified as pre-existing medical conditions, such as hypertension, diabetes, cardiovascular disease, and chronic kidney disease, documented in the patient's medical records at the time of hospital admission.

Terminal illness is a medical condition diagnosed by a qualified healthcare provider that is expected to result in death within a specified time frame, typically six months or less, despite available curative treatments.

4.9 Data Collection Plan and instruments

A pretested structured data extraction form (checklist) was used to review patient medical records and the neurosurgery registry by two specially selected and trained anesthesiology professional I clinicians. The data included the patient's medical registration number, date of admission, age, gender, ASA class, metabolic equivalent, disease characteristics, preoperative comorbidities, and postoperative complications.

To determine the primary outcome of death, death certificates were identified from the emergency and trauma registries at the hospital using medical record numbers. If a death certificate could not be located, patients or their attendants were contacted by phone to ascertain the event status. Information not available from the patient medical record or medical register was also collected during the phone interview. After data collection was complete, patients' medical records were returned to their original location

4.10 Data Quality and Control

To ensure data quality, a pre-test was conducted on 10% of the sample, and these data were not included in the main study. To ensure quality, the principal investigator checked the data for completeness, accuracy, and clarity at the time of collection. Data cleaning and cross-checking were performed before analysis. The principal investigator provided ongoing supervision throughout the process. Data collectors received a one-day training session covering the study's purpose, questionnaire content, and field procedures. Supervisors also received training in fieldwork coordination and data quality control protocols. At the conclusion of the session, each data collector administered a pre-test to familiarize themselves with the data collection tool.

4.11 Data Analysis Plan

Once the data were gathered from the medical record reviews, they were processed using STAT version 27. Descriptive statistical analyses were performed. Calculations were performed to determine the central tendency and dispersion of the continuous variables. For categorical variables, frequency distributions were determined.

Survival status was evaluated at three follow-up points: 1 month, 3 months, and 6 months after the intervention. The outcome variable (dependent variable) was categorized into two groups: death and censored. A survival table was created to estimate the likelihood of survival at different time points after surgery. The Kaplan-Meier method was used to visualize the survival function (curve), and the log-rank test was employed to determine differences in survival between groups defined by explanatory variables.

Cox regression was conducted to identify factors that predict survival time, and the goodness-of-fit of the Cox regression model was assessed via Schoenfeld residuals and log-minus-log survival plot. We excluded variables with a p-value above 0.25 from the bivariate regression analysis.

After fitting a bivariate Cox regression model, independent variables that had a p-value ≤0.25 were selected for multivariable analysis because in the initial bivariable analysis, variables with a p-value less than 0.25 were selected for inclusion in the multivariable model. This approach is taken to avoid prematurely excluding variables that might not appear significant on their own but could become important predictors once adjusted for other factors (confounders) in the more complex model. It also helps to reduce issues like model overfitting and multicollinearity, while ensuring the model remains interpretable and retains any potential predictors that have conditional effects. Multivariable Cox regression was performed at a 0.05 level of significance to determine the net effect of each explanatory variable on survival status.

The results of these models were expressed as hazard ratios (HRs) with 95% confidence intervals, and p-values were used to measure the strength of association and identify statistically significant factors. Finally, the study's findings were presented using text, tables, and graphs.

4.12 Ethical Considerations

Ethical approval was obtained from the Addis Ababa University College of Health Sciences Ethical Review Board prior to data collection. This approval was presented to the study area administration. Given the retrospective nature of the study, individual patient informed consent was not required. As the study involved reviewing medical records, individual patients were not subjected to harm, provided that confidentiality was maintained. The data collected were used solely for research purposes, and each patient's personal information was kept confidential.

To ensure confidentiality, all collected data were coded, and the questionnaires were sealed in a box and stored in a secure location accessible only to the lead investigator until data entry. Once entered into statistical software, the data were secured with a strong password, and only the principal investigator and advisors had access. Patient records were returned to their original location after the completion of the research. One qualified Anesthesiology Professional I Clinician was selected to collect the data.

4.13 Result Dissemination Plan

Upon completion, the study findings were submitted to ALERT, TASH, and the School of Anesthesia. Efforts were made to publish the results in academic journals and disseminate them through scientific publications. Additionally, the findings were shared with hospital administrations and national policymakers through presentations and discussions.

5. RESULT

5.1 Analysis

A retrospective cohort study using STATA version 27 evaluated survival and mortality predictors in TBI patients who underwent DC, with time to death as the primary outcome and censored data for survivors or those lost to follow-up. Kaplan-Meier survival estimates were compared using the log-rank test ($p < 0.05$), and Cox regression identified independent mortality predictors ($p < 0.05$ in multi-variate analysis), quantified by adjusted hazard ratios (95% CIs), the proportional hazards assumption checked via Schoenfeld residuals (global $p > 0.05$); the likelihood ratio test (Chi-square = 12.37, p = 0.1354) indicated good overall model fit and log-minus-log survival plot. This involved looking at the survival curves for different groups (like those with varying Glasgow Coma Scale (GCS) scores) and seeing if they ran roughly parallel to each other over time. If they were parallel, it suggested the assumption was met.

5.1.1 Demographic Characteristics

Of the 121 subjects in the study, 82.8% were male and 16.4% were female. Most of the subjects (91.0%) were between 18 and 60 years old and only 8.2% were older than 60 years old. In terms of hospitals; 50.8% of the cases were managed at ALERT Hospital and 48.4% were treated at Tikur Anbessa Specialized Hospital (TASH).

5.1.2 Clinical and Management Characteristics

At presentation, 45.1% of our cohort presented with Glasgow Coma Scale (GCS) scores of 13-15 and 45.9% presented with GCS scores between 8-12. In terms of pupillary reactivity, 49.2% had bilateral reactive pupils, 47.5% had unilateral reactivity, and 2.5% had non-reactive pupils. Road Traffic Accidents (RTA) was the most common cause of traumatic brain injury accounting for 74.6%, followed by assault (15.6%) and falls (9.0%). Concerning intraoperative blood loss (IBL), 50.0% of patients lost between 500-1000 ml of blood, 46.7% lost <500 ml and 2.5 % lost >1000ml. Haematocrit levels were within 30-45% for 78.7% of patients with 20.5% recording haematocrit levels <30%. For serum sodium concentration, 73.0% of the patients had normal serum sodium levels (130-150mmol/L) while 20.5% had hyponatremia (<130mmol/L) and 5.7% had hypernatremia(>150mmol/L) Intracranial infection was reported in 9.8% of the study population. 52.5% of patients were induced with propofol, 45.1% of patients were induced with ketamine. Intraoperative hypotension occurred 9.0% of patients. Mannitol was administered to 65.6% of their patients intraoperatively.

Of the patients who received blood transfusion, 61.5% percent of patients did not receive any transfusion, 34.4% received less than four units of blood transfusion, and three-point three percent received more than four units of blood transfusion. Anesthesia-related complications occurred in 5.7% of patients. 73% of patients were admitted to the ICU postoperatively. Additionally, 19.7% of patients were mechanically ventilated postoperatively. Re-craniotomy in 3.3% of patients occurred during the follow-up.

Table 2 demographic Characteristic Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

Variable		Frequency	Percent
Hospital	ALERT	62	50.8
	TASH	59	48.4
Sex	Male	101	82.8
	Female	20	16.4
Age	18-60	111	91.0
	>60	10	8.2

Table 3: clinical and management character Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

Variable		Frequency	Percent
GCS	13-15	55	45.1
	8-12	56	45.9

Pupil	bilateral reactive	60	49.2
	unilateral reactive	58	47.5
	none reactive	3	2.5
Cause of TBI	RTA	91	74.6
	FALL	11	9.0
	ASSULT	19	15.6
Blood loss	<500	57	46.7
	500-1000	61	50.0
	>1000	3	2.5
INDUCTION Agent	Ketamine	55	45.1
	Propofol	64	52.5
	Ketofol	2	1.6
Hypotension	No	110	90.2
	Yes	11	9.0
Mannitol	NO	41	33.6
	Yes	80	65.6
Transfusion	No	75	61.5
	<4	42	34.4
	>4	4	3.3
Anesthesia complication	NO	114	93.4
	YES	7	5.7
ICU Admission	No	32	26.2
	Yes	89	73.0
MV	NO	97	79.5
	Yes	24	19.7
RE Craniotomy	No	116	95.1
	Yes	4	3.3

Infection	No	109	89.3
	Yes	12	9.8
HCT	<30	25	20.5
	30-45	96	78.7
Na+	<130	25	20.5
	130-150	89	73.0
	>150	7	5.7

5.1.3 Survival Variable: time(month)

Life table survival analysis was used to investigate the probability of survival over time among TBI patients who had undergone craniotomy. 121 patients entered the study at time zero. By the end of the first month, there had been 19 terminal events, giving a survival proportion of 0.84 during that interval. The cumulative probability of survival fell to 0.83 at the second month, and continued a decreasing trajectory of 0.78 at the sixth month. The number of terminal events peaked at 19 during the first interval, with a hazard rate for that interval of 0.17. By the conclusion of the observation time, the cumulative Death probability was 22%, with its 95% CI: 14.6% to 29.4%**),** with 6 months.

Table 4:life table for cumulative survival probability and probability density across follow-up intervals Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

Interval Start Time	Number Entering Interval	Number of Terminal Events	Cumulative Proportion Surviving at End of Interval	Probability Density	[95% Conf. Int.]	
0	121	0	1.00	.000		
1	121	19	.84	.157	0.7649	0.8968
2	102	1	.83	.008	0.7556	0.8900
3	101	3	.81	.025	0.7280	0.8694
4	98	0	.81	.000	0.7280	0.8694
5	98	2	.79	.017	0.7098	0.8553
6	96	1	.78	.000	0.7007	0.8483

We analysed survival probabilities over time using Kaplan-Meier survival curves for estimation and visualization. To compare the survival distributions between different patient groups, we employed the log-rank test. The results of this test (found in Table 3) revealed significant associations between survival time and the following variables: GCS score (χ^2 = 49.61, p < 0.0001), age >60 years (χ^2 = 27.94, p < 0.0001), intraoperative hypotension (χ^2 = 31.64, p < 0.0001), postoperative mechanical ventilation (χ^2 = 78.94, p < 0.0001), re-craniotomy (χ^2 = 15.77, p < 0.0001), polytrauma (χ^2 = 10.51, p = 0.0012), sex (χ^2 = 4.91, p = 0.0267), chloride level (χ^2 = 6.23, p = 0.0444), and blood transfusion (χ^2 = 5.44, p = 0.0197). We didn't find statistically significant differences related to blood loss, sodium level, induction type, RBS (Random Blood Sugar), or platelet count.

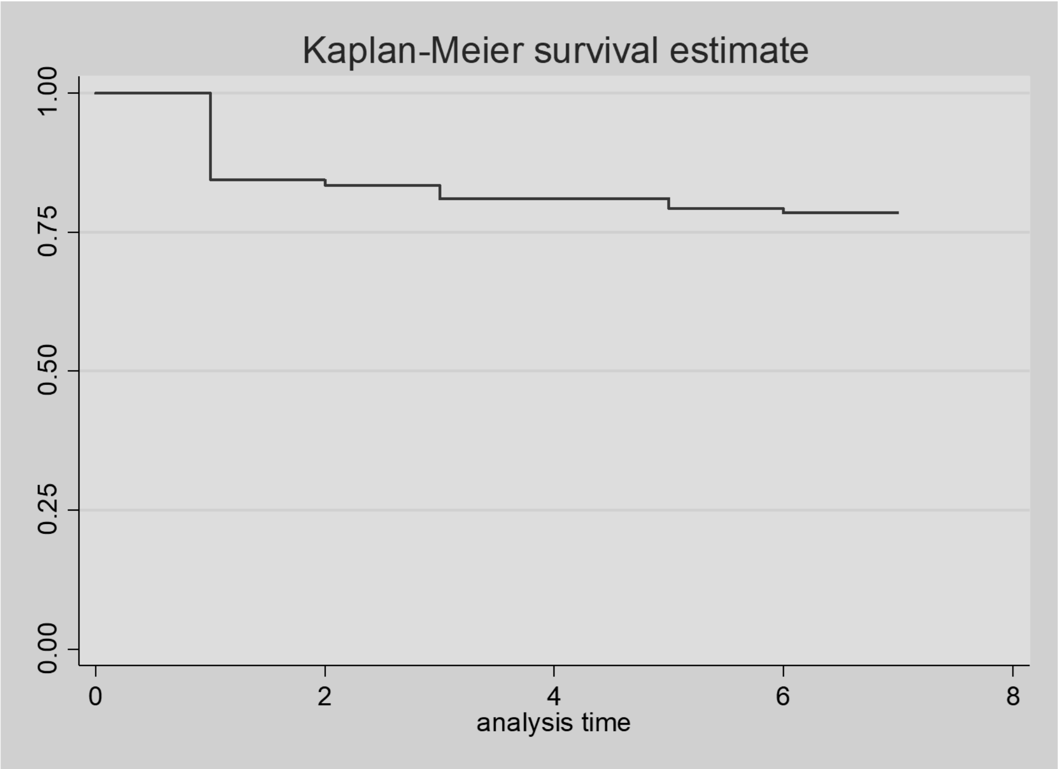

Figure 3:Kaplan-Meier survival Graph Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

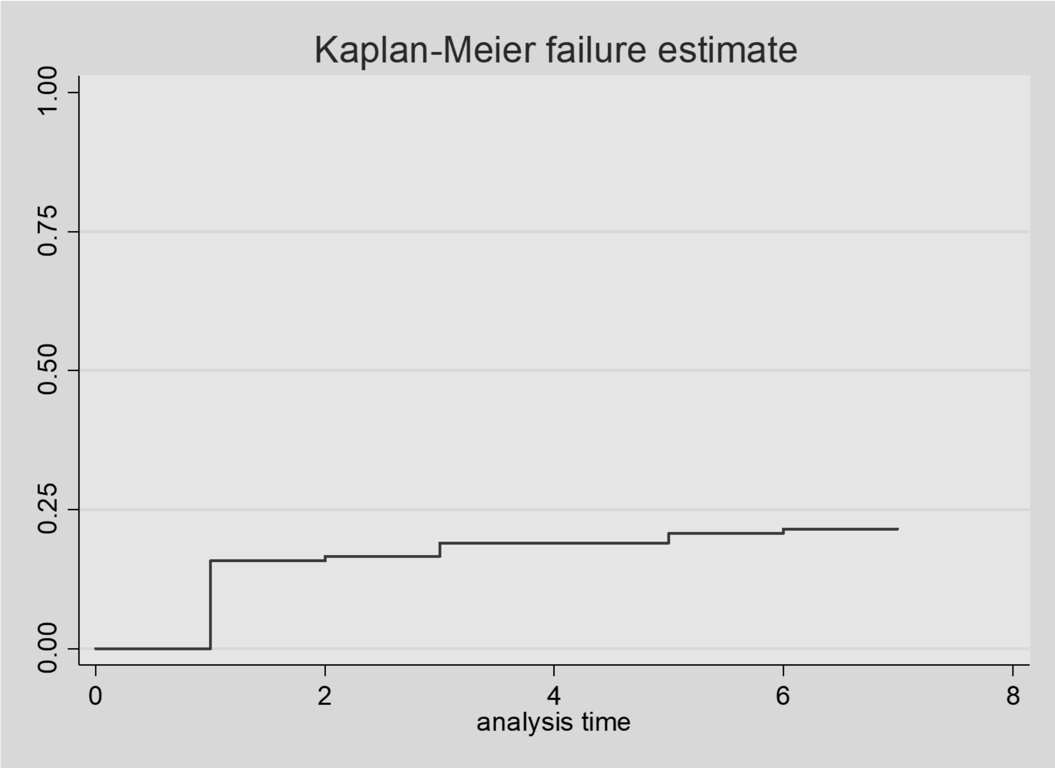

Figure 4: Kaplan-Meier Hazard Graph Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

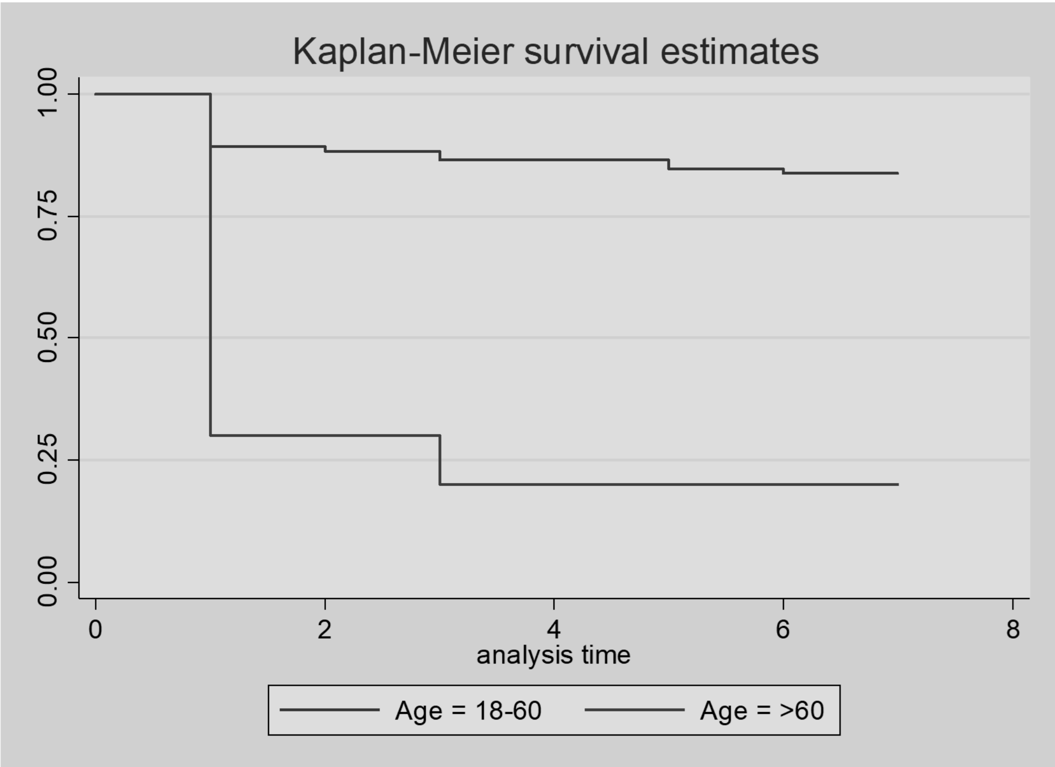

Figure 5: Kaplan-Meier Graph -effect of age on survival Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

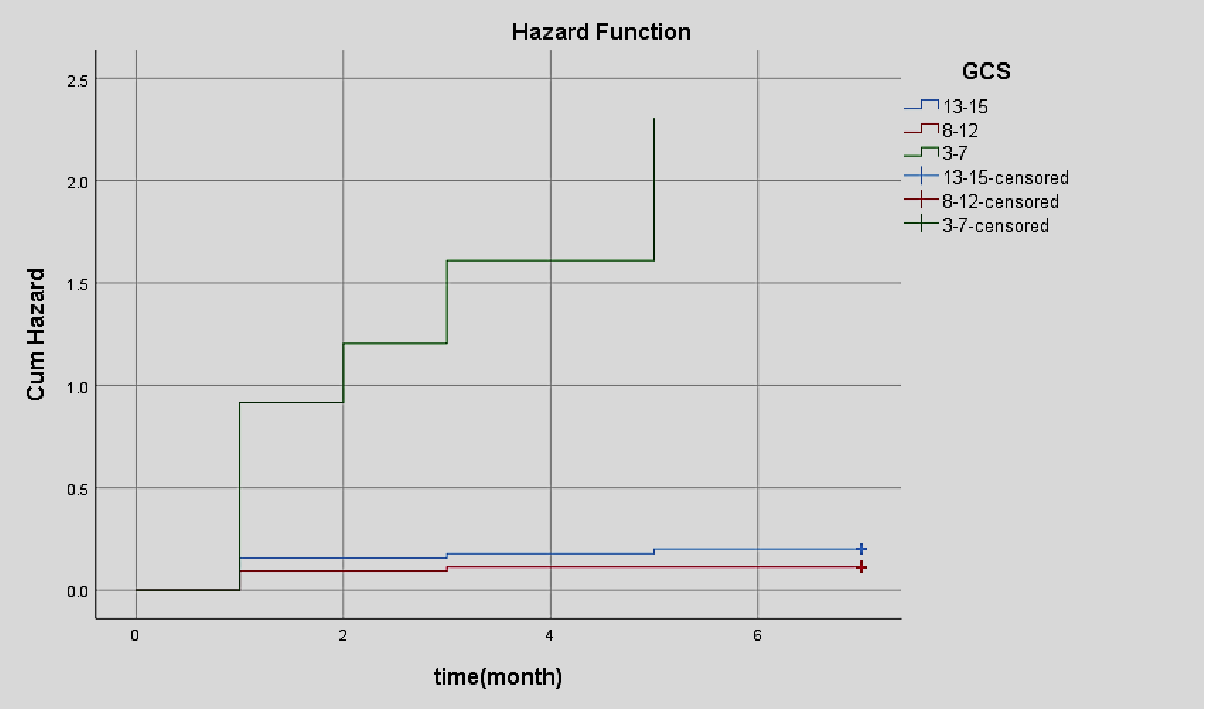

Figure 6: Kaplan-Meier Hazard Graph-effect of GCS on failure Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

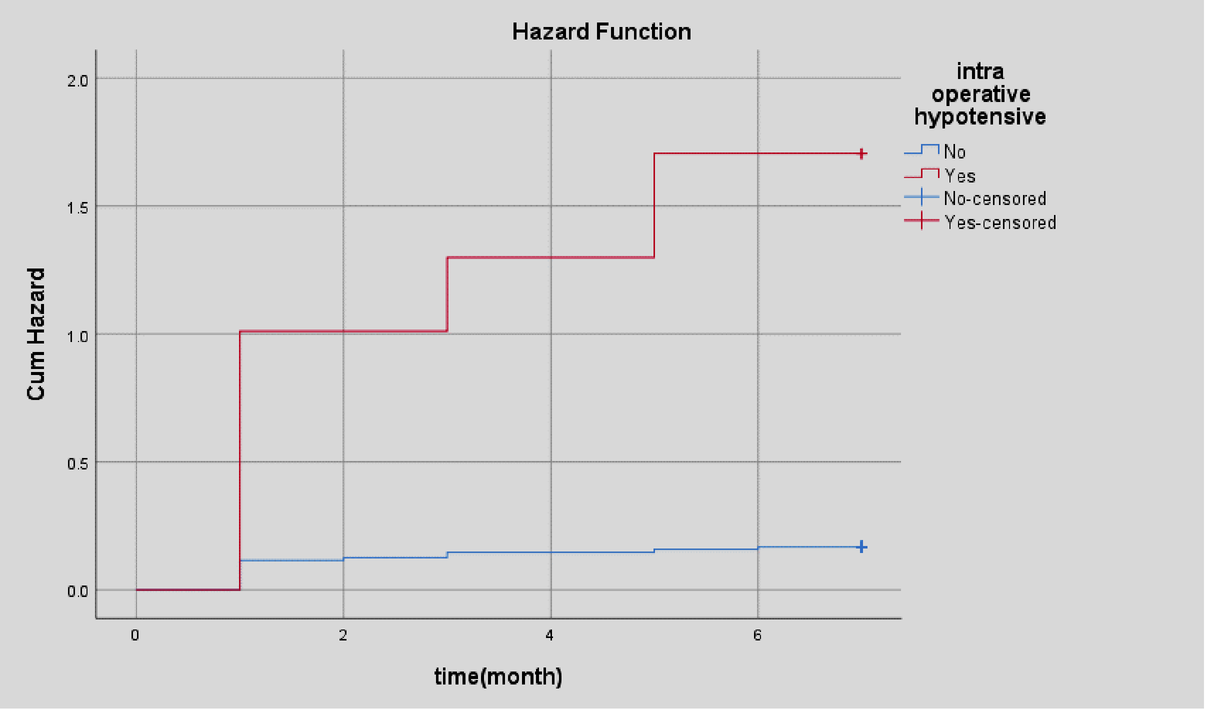

Figure 7:Kaplan-Meier Hazard Graph-effect of hypotension on failures Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

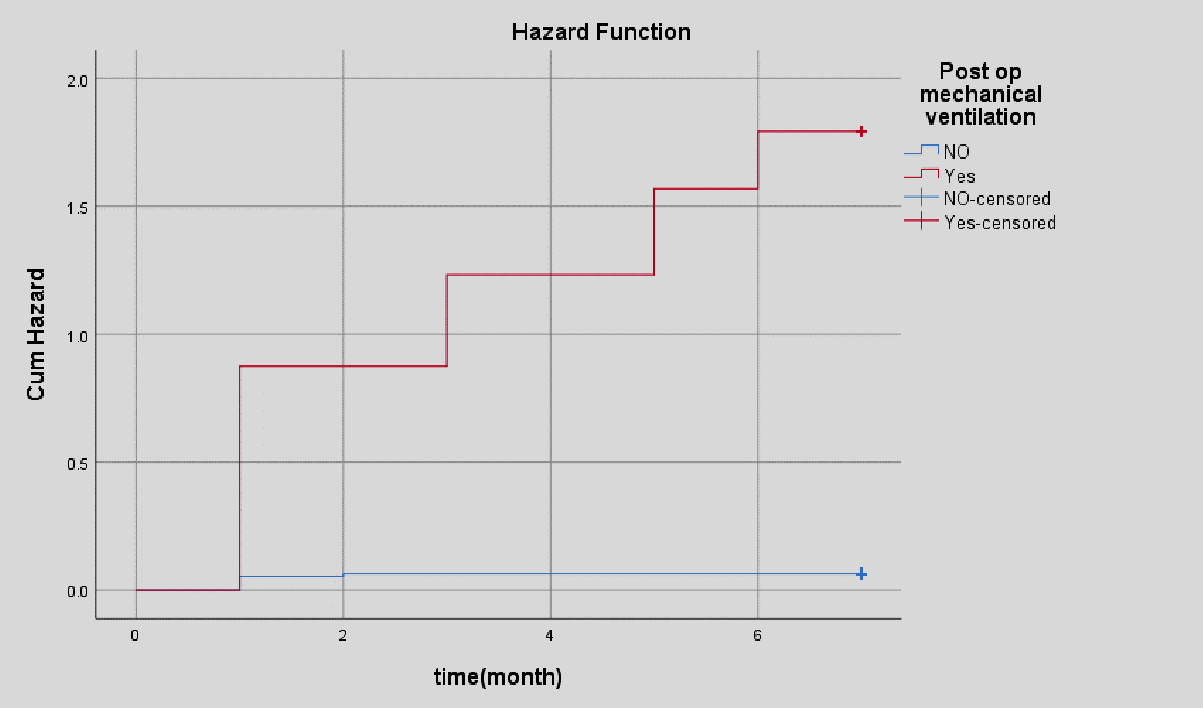

Figure 8:Kaplan-Meier Hazard Graph-effect of post op mechanical ventilation on failures Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

Table 5: Log-rank test comparing survival status among clinical variable Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

Variables	**Category**	**Event observed**	**Event expected**	χ^2	***U***	***P* value**
GCS	3-7	10	2	49.61	2	0.0001
	8-12	6	12			
	13-15	10	12			
Age	>60 years	8	2	27.94	1	0.0001
	18-60 years	18	24			
Intraoperative hypotension	No	17	24	31.64	1	0.0001
	Yes	9	2			
Postoperative mechanical ventilation	No	6	22	78.94	1	0.0001
	Yes	20	4			
Re-craniotomy performed	No	22	25	15.77	1	0.0001
	Yes	4	1			

Blood transfused	No	11	16	5.44	1	0.0197
	Yes	15	10			
Polytrauma present	No	14	20	10.51	2	0.0012
	Yes	12	6			
Sex	Male	18	22	4.91	1	0.0267
	Female	8	4			
Chlorine	<90	3	1	6.23	2	0.0444
	90-110	20	24			
	>110	3	1			
RBS	<70	1	0	1.43	2	0.4892
	70-200	19	21			
	>200	6	5			
Blood loss	<500	15	12	1.91	2	0.3848
	500-1000	10	13			
	>1000	1	1			
Sodium	<130	9	5	3.99	2	0.1359
	130-150	16	19			
	>150	1	2			
Induction type discharge	Ketamine	11	12	1.20	2	0.5493
	Propofol	14	14			
	Ketofol	1	0			
Platelet level	<100	1	2	0.81		0.3689
	>/=100	25	24			

Notes: χ^2: chi-square; $\boldsymbol{u}$: degree of freedom;

The Cox proportional hazard regression analysis identified numerous factors that were associated with mortality in craniectomies for TBI. Patients over 60-years old had a significantly worse prediction of survival. Those patients had more than 6 times the risk of dying compared to patients aged 18-60 (AHR = 6.20; 95% CI: 2.37-16.19; p = 0.001). The risk of death was also significantly increased in patients with severe TBI (GCS 3 to 7) (AHR = 6.06; 95% CI: 1.94-18.96; p = 0.002) compared to those with mild (GCS 13 to 15) TBI. There was no statistically significantly difference between groups of moderate TBI (GCS 8 to 12). Moreover, hypotension intraoperatively is a strong predictor of mortality, associated with greater than 8 times the risk of dying (AHR = 8.47; 95% CI: 2.81-25.55; p = 0.001). When ingested as a categorical ordinal variable, postoperative positive pressure ventilation predicted poorer survival (AHR = 4.71; 95% CI: 1.35-16.36; p = 0.015). Other variables, immaterial trauma, blood products, re-craniotomy and GCS 8 to 12 were significant on univariable analysis, but removed from multivariable due to common effects in confounding factors GCS score, age, hypotension, and positive pressure ventilation.

Table 6:Results of univariable and multivariable Cox-PH survival regression of Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

Variables	**Categories**	**Status**		**CHR (95% CI)**	**AHR (95% CI)**	***P* value**
		Dead	Censored			
Age	>60 years	8	2	6.45 (2.75,15.14)	6.20 (2.37, 16.19)	0.001
	18-60 years	18	93	1	1	
GCS	3-7	10	0	7.27 (2.96, 17.86)	6.06 (1.94, 18.96)	0.002
	8-12	6	50	0.57 (0.21, 1.58)	0.59 (0.18, 1.95)	0.389
	13-15	10	45	1	1	
Polytrauma present	Yes	12	16	3.12 (1.44, 6.77)	1.12 (0.38, 3.34)	0.835
	No	14	79	1	1	
Blood transfused	Yes	15	31	2.33 (1.07, 5.08)	1.70 (0.73, 3.97)	0.216
	No	11	64	1		
Intraoperative hypotension	Yes	9	2	6.75 (2.96, 15.39)	8.47 (2.81, 25.55)	0.001
	No	17	93	1		
Postoperative	Yes	20	4	18.71 (7.34, 47.67)	4.71 (1.35, 16.36)	0.015

mechanical ventilation	No	6	91	1	1	
Re-craniotomy performed	Yes	4	0	5.98 (2.04, 17.48)	1.45 (0.39, 5.41)	0.579
	No	22	95	1	1	

Notes: AHR = adjusted odds ratio; CHR = crude odds ratio; CI= Confidence interval; GCS = Glasgow coma scale

The proportional-hazards assumption was evaluated using the Schoenfeld residuals test. As indicated in the table, p-values for all covariates were above 0.05, indicating all covariates did not violate the assumption. The global test also indicated the assumption was not rejected ($X^2 = 12.37$, $p = 0.1354$). Therefore, the proportional-hazards assumption holds, meaning the Cox proportional-hazards model is appropriate for the survival analysis in this study.

Table 7:Test of proportional-hazards assumption for variable Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2019–2023) (n=121).

Variables	**Categories**	**Rho**	Chi-square	**Prob>chi2**
Age	>60 years	0.00080	0.01	0.9969
	18-60 years	1	1	
GCS	3-7	0.11259	0.39	0.5301
	8-12	-0.07342	0.19	0.6626
	13-15	1	1	
Polytrauma present	Yes	0.04943	0.09	0.7664
	No	1	1	
Blood transfused	Yes	-0.01097	0.01	0.9546
	No	1		
Intraoperative hypotension	Yes	0.18618	0.65	0.4214
	No	1		
Postoperative mechanical ventilation	Yes	0.21542	2.11	0.1459
	No	1	1	
Re-craniotomy performed	Yes	0.34376	2.93	0.0871
	No	1	1	
Global test			12.37	0.1354

To verify the proportional hazards (PH) assumption necessary for Cox regression analysis, researchers created plots of log (-log (survival probability)) against the logarithm of time for important categorical variables such as Glasgow Coma Scale (GCS) scores, patient age groups, and the presence of hypotension. A visual inspection of these plots revealed that the survival curves for different categories did not intersect and generally maintained parallel paths. This observation suggested that the PH assumption was acceptably met for these variables. This visual confirmation further supported the findings from the Schoenfeld residuals test, collectively validating the use of Cox proportional hazards modelling in this study.

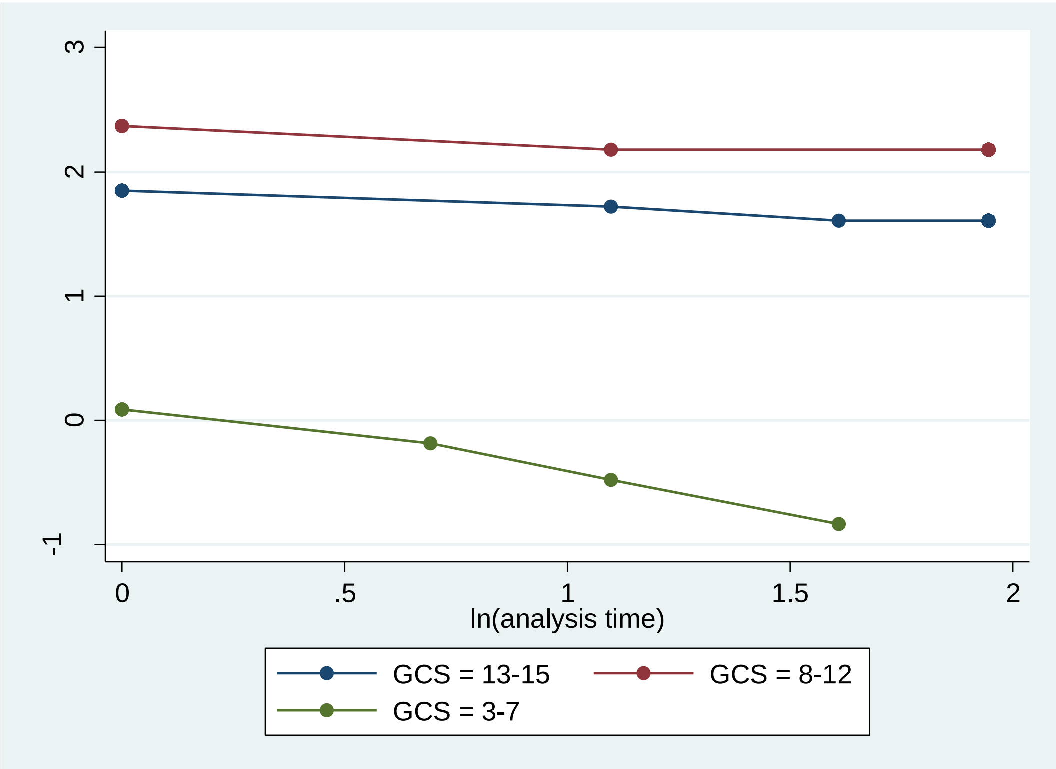

Figure 9: Log(-log) Survival Plot by GCS Severity Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2020–2023).

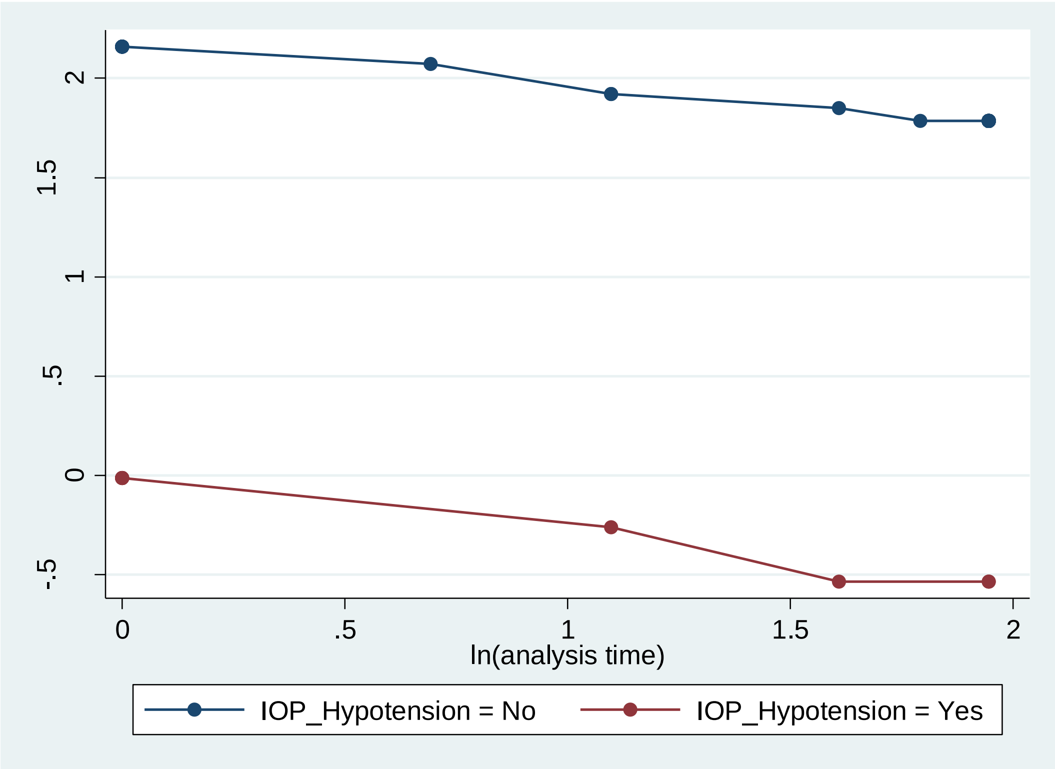

Figure 10:Figure 9: Log(-log) Survival Plot by Intraoperative hypotension Among Adults Undergoing Craniotomy for TBI at Selected Hospitals in Ethiopia (2020–2023).

6. Discussion

This study investigated survival status and its predictors in a TBI cohort who underwent craniotomy, finding a death rate of 22%, with higher mortality associated with higher age, severe TBI, hypotension during surgery and mechanical ventilation after surgery was independent predictor factor.

The total mortality for traumatic brain injury (TBI) patients who underwent a decompressive craniectomy (DC) in this study was 22% during follow-up. This figure is in comparable with previous research from around the globe and in a wide variety of health contexts. These findings show there exists a population of TBI patients that represent a global health burden, and that surgical outcomes are variable.

A similar rate of 30-day mortality (20.3%) was found in a large retrospective cohort study in the ACS NSQIP database that examined 1,634 adult TBI patients that underwent surgery from 2005 to 2017. This affinity provides external validity to our findings and suggests that DC may provide a similar survival advantage in different populations when there are appropriate clinical indications (4).

A study at Egypt's Zagazig University Hospital reported a 30.77% mortality rate for severe TBI patients who underwent decompressive craniectomy (DC). This higher rate might be due to fewer perioperative resources or more severe injuries in their patient population. In contrast, Liaocheng People’s Hospital in Pakistan found a much higher 45.5% mortality rate, possibly linked to surgical delays and lower Glasgow Coma Scale (GCS) scores before surgery. Our study's comparatively lower mortality suggests that earlier surgical decisions and more structured perioperative care in our setting likely contributed to better outcomes(3).

In contrast, a study from Liaocheng People's Hospital, Pakistan found a notably higher mortality rate of 45.5%, with 37% of deaths within the first 30 days. The high mortality may be related to the low mean preoperative GCS (5.24), delayed surgery, or limited access to critical care. Compared to this study, we report a relatively better short and medium-term survival, possibly related to earlier surgical decision-making or a more efficient perioperative support**.**

A retrospective study of 1,220 patients with TBI at Hawassa University Hospital showed a death rate of 14.3% for non-surgically managed patients compared to 4.44% mortality rate for neurosurgical managed patients. While that study was not all about patients who had DC and had a broader focus on TBI patients, it supports the important life-saving potential of surgical decompression in patients select appropriately for the procedure.

The overall mortality rate in our study of 22% is within the 4.4% to 45.5% observed globally. This shows that outcome following TBI is multifactorial and goes beyond the presence or absence of craniotomy and/or decompressive craniectomy. Timing of the surgical procedure, severity of the injury and comprehensive immediate postoperative care also all impact mortality rates. The results also substantially indicate that decompressive craniectomy may be life-saving for a TBI victim, particularly if this procedure was performed in a timely fashion and with appropriate perioperative care.

This study examined potential predictors of mortality in patients with traumatic brain injury (TBI) undergoing decompressive craniectomy. The primary independent predictors of mortality found were age, usual low Glasgow Coma Scale (GCS) scores, intraoperative hypotension, and postoperative mechanical ventilation.

Patients over 60 years of age had significantly worse survival outcomes than those aged 18-60 years. Specifically, patients over 60 years of age were more than six times more likely to die than those aged 18-60 years (AHR = 6.20; 95% CI: 2.37 - 16.19; $p = 0.001$). This finding is consistent with the results of an analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database in which patient age was a strong 30-day mortality predictor in TBI patients undergoing surgery (4). Similarly, a prospective cohort study in India reported a 100% mortality rate among patients over 55 years with severe TBI who underwent craniotomy (20). These findings demonstrate older patients are particularly vulnerable due to decreased physiological reserve, increased comorbid conditions, and limited capacity for neurological recovery after TBI.

The Glasgow Coma Scale score was another important predictor of mortality. Patients with a severe TBI (GCS 3–7) were over six times more likely to die compared to patients with mild TBI (GCS 13–15) (AHR = 6.06; 95% CI: 1.94–18.96; $p = 0.002$). Moderate TBI (GCS 8–12) was associated with a higher risk of death, but this was not statistically significant. Similar findings have been reported in multiple studies. For example, in a retrospective study from Hawassa University, compared to patients with mild TBI, patients with a moderate and severe TBI had a significantly higher risk of mortality (AHR for severe TBI = 8.8) (3). Moreover, in a pediatric ICU setting in India, GCS score ≤ 8 after resuscitation was found to independently predict poor outcomes (18). The Glasgow Coma Scale (GCS) is essential for quickly assessing TBI patients. It should dictate how urgently surgery is performed and how intensely postoperative care is provided. By creating standardized care protocols based on GCS severity, we can better allocate resources, such as prioritizing ICU beds and neuromonitoring for those with severe TBI.

Intraoperative hypotension was one of the strongest predictors in this study and increased risk of death by over eight times (AHR = 8.47; 95%CI: 2.81–25.55; $p = 0.001$). This finding supports a prospective study from India that also reported intraoperative hypotension to be an important predictor of poor outcome in patients undergoing craniotomies (20). The role of hypotension as a contributor to secondary brain injury is well studied and theoretically makes sense as it leads to diminished cerebral perfusion resulting in increased ischemic damage and mortality. Managing blood pressure meticulously during craniotomy for TBI is crucial. Anesthesia and surgical teams should implement goal-directed fluid therapy and vasopressor protocols to prevent hypotension. For high-risk patients, prioritizing training and continuous monitoring with arterial lines is essential. Hospitals also need to ensure their operating rooms are equipped with dependable hemodynamic monitoring tools.

Additionally, we found that postoperative mechanical ventilation was independently associated with mortality (AHR = 4.71; 95% CI: 1.35–16.36; $p = 0.015$). Mechanical ventilator support may serve as an indicator of severity of initial brain injury or perhaps postoperative complications which have progressed to respiratory or infection failure. We also made a similar finding in the Indian pediatric ICU study, which observed that longer NICU stays, often indicative of mechanical ventilation, were associated with higher mortality. Early identification of patients who'll likely need mechanical ventilation is crucial. Hospitals should set up clear protocols for weaning patients off ventilation and extubating, while also emphasizing infection prevention strategies. Mechanical ventilation can also serve as a proxy for the severity of a patient's critical illness, prompting a multidisciplinary management approach (18).

Variables such as blood loss, transfusion, ICU admission (vs ward admission) and intracranial infection were measured in our data, but did not have significant multivariable correlations to survival. This could be attributed to sample size limitations and potential interaction with other stronger predictors such as GCS and hypotension.

Comparing our findings with the findings of Felegehiwot Comprehensive Specialized Hospital which reported an AHR of 3.48 for age 65 and older and AHR of 1.72 for hypotension patients (1), our study has reported AHR even stronger than theirs, especially for hypotension and low GCS. Differences in AHR could be related to patient population, timeframes of surgery, or management protocols within each facility.

7. Limitation

this study has a few key limitations. For starters, the small sample size means our findings might not apply broadly and we might have missed some weaker connections. Also, because it was a retrospective study, we could only use what was already in patient charts, which led to missing information and incomplete records. Lastly, the quality of medical documentation varied across hospitals, which could affect how accurate and complete our data is. Keep these limitations in mind when looking at our conclusions; they also point to the need for future, larger studies with consistent data collection.

8. Conclusion

In conclusion, we found a 22% mortality rate for TBI patients undergoing craniotomy, with both non-modifiable factors (advancing age and severe TBI) and modifiable factors (intra-operative hypotension and mechanical ventilation use in the post-operative period) significantly contributing to mortality. This highlights the importance of early identification of patients likely to experience mortality, and targeted interventions aimed at modifiable factors, including intra-operative optimization and post-operative critical care, to minimize preventable mortality and improve outcomes for patients undergoing craniotomy for TBI, particularly in low-resource settings

9. Recommendations

Given the 22% mortality rate and identified modifiable (i.e. intraoperative hypotension, postoperative ventilation) and non-modifiable (i.e. age, severe TBI) predictors of death in TBI patients undergoing craniotomy, we recommend that policymakers and health ministry's invest in trauma and neurosurgical facilities and staff, mandate uniform TBI protocols, enhance capacity building for health service providers, and agree on TBI indicators; clinicians invest in increased intraoperative monitoring, enhanced perioperative care, and develop multidisciplinary systems of care to reduce preventable death; and researchers conduct prospective interventional studies addressing long term functional recovery, emergency/prehospital care, and context specific strategies to improve survival rates in resource limited settings.

10. TENTATIVE WORK PLAN

The tasks to be performed are illustrated in the following Gantt chart

	Task to be Performed	Responsible Person	June-July ,2024	August-September, 2024	October-December, 2024	Jan-March,2025	February-may, 2025	May-june 2025	June ,2025
1.	Topic Submission	Investigator							
2.	Review Literature	investigator							
3.	Submission of 1st draft proposal to Advisor	investigator							
4.	Submission of final draft proposal to School of Anesthesia	investigator							
5.	Ethical clearance	AAU and Anesthesia Dept							
6.	Data Collection by using Checklist	Anesthesiology Professional I clinicians							
7.	Data Analysis Report result to advisor and discuss about it	Principal investigator							
8.	Final thesis submission to School of Anesthesia	Principal investigator							
9.	Thesis Defence	Principal investigator							

11. BUDGET PROPOSAL BREAKDOWN

1. Training of Data collector				
Descriptions	Number	Unit Price	Multiplying factor	Total cost (Eth. Birr
Daily fee for trainer	1	500	1*500	500
Daily fee for data collectors (2 Anesthesiology professional I clinicians)	2	200	2*800	1600
2. Personnel Costs during data collection				
Allowance for Supervisor	1	40 birr per questionnaire	1*40*300	12000
Allowance for data collectors	2	40 birr per questionnaire	2*40*120	9600
3. Materials				
Pen	10	20 per piece	10*20	200
Duplication of questionnaire	400	3 birr per questionnaire	400*3	1200
Binder	2	100 per piece	2*100	200
A4 paper	50	3 birr each	3*50	150
Total price				25,250

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13. ANNEX

ANNEX 1: Information Sheet English Version

Title of the Research Project: Survival Status and Predictor Factors in Traumatic Brain Injury (TBI) Patients Undergoing Craniotomy: A Retrospective Cohort Study at Tikur Anbessa Specialized Hospital (TASH from 2019-2023 GC Ethiopia, Addis Ababa

Name of Principal Investigator: Sisay Dedefo Bachelor of Science in Anesthesia and Master of Science candidate in Advanced Clinical Anesthesia, Addis Ababa University.

Contact phone number: +251939747803

Email: Sisaydedefo572@gamil.com

Name of the Organization: Addis Ababa University, College of Medicine and health science, Department of Anesthesia

Introduction: We would like to extend an invitation to you to participate in a research project that aims to assess the survival status and identify predictive factors among patients who have undergone craniotomy due to traumatic brain injury (TBI). Please take the time to carefully read this information sheet to understand the purpose of the study and what your involvement entails

Purpose of the Study: The purpose of this study is to evaluate the outcomes of patients with traumatic brain injury (TBI) who have undergone craniotomy and to identify factors that predict survival and recovery. This study uses data collected from medical records and does not involve direct contact with patients.

Procedure: You have been identified as a patient who underwent a craniotomy for traumatic brain injury at Tikur Anbessa Specialized Hospital (TASH) in Addis Ababa, Ethiopia, between 2019 and 2023. As part of our investigation, we are reviewing the medical records of these patients.

Risk and /or Discomfort: This study won't involve any new tests or procedures. We'll only be using information that's already in your medical records, so there's no risk to you.

What was happen if I take part in this study?
Since this is a retrospective study, we **will use** information from your medical records, including:

- Demographic information (age, sex, etc.)
- Clinical information (TBI severity, craniotomy details, intra-operative and post-operative care)
- Survival status and follow-up data

No additional procedures or interventions are required from you as a participant

Confidentiality: All information collected for the study was be kept strictly confidential. Your identity was not be revealed in any reports or publications resulting from this study. Data was be anonymized to protect your privacy.

Right to Refusal or Withdraw: Your participation in this study is completely voluntary. If you choose not to take part, it will not affect the medical care you receive or your relationship with Addis Ababa University. You are also free to withdraw from the study at any time, without needing to provide a reason.

Result and benefit of study: Although this study will not directly benefit you, the results may help improve treatment and outcomes for future patients with head injuries who require brain surgery. The findings will be shared through medical journals and scientific conferences, and your personal information will be kept strictly confidential in all reports and publications.

Person to contact: If you have any further questions or would like to receive further information about the project, please contact:

1. Sisay Dedefo (Principal investigator): +2519397478
2. Ms. Senait Awoke (BSc, MSc, Ass. Professor in anesthesia) (Advisor)
3. Ms. Wubayehu (BSc, MSc in anesthesia) (Advisor)

Thank you for reading the Information Sheet, and asking any questions that you might have had.

ANNEX2: Information sheet Amharic Version

ANNEX 3: Consent Form English Version

Consent:

By agreeing to participation of your hospital in this study, you're confirming that you understand what we've explained. Because this study uses your past medical records, you don't need to sign any additional paperwork. We'll keep your client information private and anonymous. Your participation is voluntary, and you can stop at any time. You agree to let us use your medical records for this study. You've read and understood what this study is about, what it was involve, and any possible risks

A) YES B) NO

Participant's Name: ___________________________

Signature: ___________________________

Date: ___________________________

for Investigator Use:

Researcher's Name: _____________________________

Signature: _____________________________

Date: _____________________________

ANNEX 4: Consent Form Amharic Version

በዚህ ጥናት ውስጥ የሆስፒታልዎን ተሳትፎ በመስማማት የገለፅነውን መረዳትዎን እያረጋገጡ ነው። ይህ ጥናት ያለፉትን የህክምና መዝገቦችዎን ስለሚጠቀም፣ ምንም ተጨማሪ ወረቀት መፈረም አያስፈልግዎትም። የደንበኛዎን መረጃ ሚስጥራዊ እና የማይታወቅ እናቆየዋለን። የእርስዎ ተሳትፎ በፈቃደኝነት ነው, እና በማንኛውም ጊዜ ማቆም ይችላሉ. ለዚህ ጥናት የህክምና መዝገቦችዎን እንድንጠቀም ተስማምተሃል። ይህ ጥናት ስለ ምን እንደሆነ፣ ምን እንደሚያካትተው እና ሊከሰቱ የሚችሉ አደጋዎችን አንብበው ተረድተዋል።።

ሀ) አዎ ለ) አይ

የተሳታፊው ስም:- _______________________________

ፊርማ: ________________________________

ቀን:- ____________________

ለተመራማሪ አጠቃቀም:-

የተመራማሪ ስም:- _____________________________________

ፊርማ: ________________________________

ቀን:____

ANNEX 5: Data Collection Tool

PART I: Questions on socio-demographic and physical characteristics of the patient

Sr.no	**Questions**	**Response**	**Code**
1.	Age	Years	
2.	Sex	Male Female	
3.	ASA physical status	_____	
4.	co-morbidity	Yes No	
5.	If yes; specify the disease		

PART III: Questions on Trauma related factor

Sr.no	**Questions**	**Response**	**Code**
6.	GCS (Glasgow Coma Scale) at admission		
7.	Pupillary reaction	1) Bilateral reactive 2) Unilateral reactive **3)** Bilateral non- reactive	
8.	Time between trauma and Surgery	_______hr_____min	
9.	Type of trauma		
10.	Polytrauma	1) Yes **2) No**	
11.	If yes specify area injury other than TBI		
12.	seizures	YES NO	
13.	Cause of Traumatic Brain Injury	1) Road traffic accident	

	(TBI	2) Fall 3) Assault **4)** Other	

PART II: Questions on anesthesia and surgery related factor

Sr.no	**Questions**	**Response**	**Code**
14.	blood loss	**______ml**	
15.	Duration of surgery	**____hr___min**	
16.	Type of craniotomy	**1) Decompressive** **2) hematoma evacuation** **3) removal of damaged tissue**	
17.	Random blood sugar	**_____mg/dl**	
18.	Induction agent		
19.	Episode Hypoxia Spo2 <94%		
20.	Episode intra operative Hypertension SBP<90 or DBP<60	**1) Yes** **2) No**	
21.	Episode intra operative hypotensive SBP>140 or DBP>90	**1) Yes** **2) No**	
22.	Vasopressor	**1) Yes(Name)________** **2) No**	
23.	Timing of craniotomy	**1) Elective** **2) Emergency**	
24.	Blood Product Transfusion	1) YES (------ml) **2)** NO	
25.	Total perioperative fluid	_____ml	

26.	Average Body Temperature	_______◦C	
27.	Mannitol is administered	1) Yes 2) No	
28.	total duration of anesthesia?	**__hr___min**	
29.	Were there any complications related to anesthesia during the surgery?	**1) Yes** **2) No**	
30.	If yes specify it		

PART II: Questions on Post-Operative and Long-Term Outcomes

Sr.no	**Questions**	**Response**	**Code**
31.	Intensive care unit (ICU) admission	**1) Yes** **2) No**	
32.	Post op mechanical ventilation		
33.	Re-craniotomy	**1) Yes** **2) No**	
34.	Intracranial infections	**1) Yes** **2) No**	
35.	Survival status at discharge and follow-up	**1) Death** **2) Survived**	
36.	If death time of death post operatively		

Laboratory result

37.	Cr	___mg/dl	
38.	Urea	____mg/dl	
39.	Na+	____mmol/l	
40.	K+	____mmol/l	

41.	Cl-	____mmol/l	
42.	ALT	____u/l	
43.	ALP	____u/l	
44.	Albumin	_____g/dl	
45.	Hgb	_____g/dl	
46.	Hct	____%	
47.	PLT		

Patient ID	Age	Sex	GCS	ASA	Co-mor	Pup rxn	Time	Poly	Cause	B .lose	Dura tion	RBS	HTN	HYPOTENSIV	TRANSFUSION	ICU	REOPERATION	Sepsis	Outcome	Death time

ANNEX 6: Result input Table 6.1