



Original Article

Management and outcomes of anterior skull base fractures with cerebrospinal fluid leak

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ABSTRACT

Objectives: The objective of the study is to report our experience in managing anterior skull base fractures (ASBF) with cerebrospinal fluid leak (CSF) leakage in a resource-limited setting.

Materials and Methods: This retrospective study included 43 patients diagnosed with ASBF and CSF leakage at Donka National Hospital between January 2015 and December 2021. Data were collected from the patient files, operative reports, and imaging studies. Clinical presentation, injury mechanism, imaging results, treatment, and outcomes were analyzed. Statistical analyses were performed using descriptive and analytic methods.

Results: The mean age of the participants was 38 ± 12 years (65% male). The injury mechanisms included road traffic accidents (70%), falls (25%), and assaults (5%). Acute rhinorrhea (74%) and delayed leaks (12%) were the most common presentations. Meningitis was observed in 28% of cases. The diagnosis was clinical in 14% of patients, while 80% underwent computed tomography scans. Fractures were classified using the Fain and Peri system. The antibiotics used were ampicillin (86%) and ceftriaxone (14%). Surgical intervention (58%) had a mean 5-day delay, and 32% occurred >7 days after the decision. The overall mortality rate was 14%. Mortality predictors included Glasgow Coma Scale score ≤ 8 (odds ratio [OR] = 4.8) and meningitis (OR = 3.6). At the 12-month follow-up, 64% of the surgical group had an excellent outcome, with complete resolution of the leak.

Conclusion: ASBF with CSF leakage in Guinea presents significant challenges, including delayed care and limited resources. Early diagnosis and timely surgical intervention are crucial for improving outcomes. Improvements in pre-hospital care, antibiotic access, and endoscopic training are critical.

Keywords: Anterior skull base fracture, Cerebrospinal fluid leak, Meningitis, Traumatic brain injury

INTRODUCTION

Anterior skull base fractures (ASBFs) with cerebrospinal fluid (CSF) leaks represent a critical neurosurgical emergency, carrying risks of meningitis, pneumocephalus, and death.^[1] In high-income countries (HICs), mortality rates are <5% due to advanced imaging, endoscopic repair, and prophylactic antibiotics.^[2] However, in low-income countries (LICs), outcomes remain dismal, with mortality due to delayed care, limited imaging, and scarce neurosurgical expertise.^[3] Guinea's healthcare system faces significant constraints due to limited infrastructure and funding, and unique challenges in managing traumatic brain injuries (TBIs).^[4] Road traffic accidents (RTAs), driven by poorly regulated motorcycle transport, account for the majority of TBI.^[5] Guinea has 17 neurosurgeons, all residing in the capital, and less than five computed tomography (CT) scan equipment, all located in

the capital, causing over-reliance on clinical diagnosis in rural areas and exacerbating delays. This study, the first in Guinea, analyzed 43 ASBF patients managed over 7 years, with the aim of reporting our experience of care in a country with limited health resources.

MATERIALS AND METHODS

This study was conducted at the Donka National Hospital from January 2015 to December 2021. The hospital has limited intensive care unit (ICU) capacity, rudimentary neurosurgical equipment, and no endoscopy equipment. Healthcare financing is solely dependent on the patients and their families. There is no centralized pre-hospital care for TBI in the country. All cases of ASBF with clinically or radiologically confirmed CSF leak were retrospectively examined. Patients with associated middle fossa fractures

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or CSF leaks, and those with incomplete records were excluded. Data were collected from patient files, operative reports, and imaging studies. Clinical presentation (CSF leak, meningitis, Glasgow coma scale [GCS]), injury mechanism, imaging results (CT availability, pneumocephalus, Fain et Peri Classification), treatments (conservative with bed rest and antibiotics or surgical by craniotomy with duroplasty), and outcomes (CSF leak resolution, complications, and mortality) were among the relevant data collected. The statistical analyses were descriptive and analytical. Continuous variables were summarized as means and standard deviations for normally distributed data. Categorical variables are presented as frequencies and percentages and were compared using Fisher's exact test. Survival analysis techniques were employed to evaluate time-to-event outcomes, with differences between groups stratified by treatment modality (conservative vs. surgical), Fain and Peri classification, and GCS range assessed using the log-rank test with a primary endpoint determined as all-cause mortality within 12 months. Multivariate Cox proportional hazards regression modeling was performed to adjust for clinical and demographic confounders and identify independent predictors of mortality and unfavorable functional outcomes defined by moderate-to-severe disability. Variables with a $P < 0.1$ in univariate analysis were entered into the multivariate model. Hazard ratios (HRs) and odds ratios with 95% confidence intervals are reported. Data were analyzed using R. The anonymity of the patients was preserved, and the study was exempted from the obligation to obtain ethical approval by the ethical committee of Donka National Hospital's institutional review board (decision number 0047 of June 2, 2025).

RESULTS

The mean age of the study participants was 38 ± 12 years, and 65% were male. The mechanisms of injury included RTAs (70%), falls (25%), and assaults (5%), with motorcycle accidents contributing significantly to RTAs (83%). The occupational profile indicated that 44% were manual laborers and 26% were unemployed, and patients presented with CSF leaks, including acute rhinorrhea (74%) and delayed leaks (12%). Notably, 16% of the patients exhibited neurological deficits, and 28% had meningitis upon admission.

The diagnosis was strictly clinical in 14% of the patients, while 80% underwent CT scans. Fractures were classified using the Fain and Peri classification system, revealing distinct patterns based on fracture complexity and location [Table 1]. CT scans identified 51% cerebral contusions, 35% acute subdural hematomas, and 23% pneumocephalus.

Antibiotics administered included ampicillin (86%) and ceftriaxone (14%). Surgical interventions were performed in

58% of the cases ($n = 25$ only for ASBF), with a mean delay of 5 days (range 1–14 days), and 32% of the patients underwent surgery > 7 days after the surgical decision was made. Table 1 summarizes the demographic and clinical data of this study [Table 1].

At the 12-month follow-up, 64% of the surgical group had an excellent outcome with complete resolution of the leak and no disability according to the Glasgow Outcome Scale, but the difference did not reach statistical significance compared to conservative treatment [Table 2].

The overall mortality rate is 14%, primarily due to sepsis and meningitis. Orbitosphenoidal extension of the fracture (Fain et Peri type III) and a GCS score < 8 were statistically significant factors of mortality ($P = 0.002$ for the former and < 0.001 for the latter) [Table 3].

Multivariate analysis showed that patients with a GCS ≤ 8 , Fain et Peri type III fracture, and early meningitis had an increased risk of mortality on HR evaluation [Table 4].

DISCUSSION

The management of ASBF with CSF leaks in Guinea reflects both the unique challenges of LICs and universal complexities of neurotrauma care. This study, conducted over 7 years in one of the two main neurosurgical centers in Guinea, provides critical insights into epidemiology, clinical outcomes, and systemic barriers, which we contextualize here using comparative data from regional and global literature.

The predominance of young males affected in our cohort aligns with worldwide trends, likely due to increased exposure to high-energy trauma from activities such as transportation and construction.^[6] Motor vehicle accidents were identified as the leading cause, particularly those related to motorcycles, mirroring the pattern in many African countries where rapid urbanization and increasing motorization occur without commensurate improvements in road safety infrastructure.^[6,7] This observation is further substantiated by research conducted in Côte d'Ivoire, which highlights the significant role of motorcycle accidents in head trauma.^[6] Assault was the second leading cause in our series, consistent with studies from other urban centers in Africa.^[3] This underscores the importance of addressing the socioeconomic factors contributing to violence as part of a comprehensive public health strategy.

The predominance of RTAs mirrors the findings across sub-Saharan Africa. In Nigeria, Adeleye and Olayemi (2010)^[8] reported that 68% of basilar skull fractures resulted from RTAs, primarily involving motorcycles. Similarly, Bouchaouch *et al.* (2015) in Morocco noted that 62% of ASBF cases were linked to RTAs, underscoring regional road safety failures.^[7] By contrast, HIC studies, such as

Table 1: Clinical, epidemiological, and paraclinical data summary of the series (n=43).

Variable	Summary
Age (years), Mean±SD	38.1±12.2
Sex, n (%)	23 (53) Male 18 (42) Female 2 (5) Hermaphrodite
Injury mechanism, n (%)	7 (16) Motorcycle accident 6 (14) Car accident 4 (9) Assault 4 (39) Fall 3 (7) Truck accident 3 (7) Pedestrian accident
Clinical presentation, n (%)	18 (42) Acute rhinorrhea 9 (21) Delayed rhinorrhea 9 (21) Rhinorrhea with meningitis 2 (5) Olfactory deficit 2 (5) Visual deficit
GCS, n (%)	13 (30) GCS 3–8 (severe) 13 (30) GCS 9–12 (moderate) 17 (40) GCS 13–15 (mild)
Fracture classification, n (%)	18 (42) Type I 12 (28) Type II 12 (28) Type III
Associated lesions, n (%)	11 (26) Subdural hematoma 9 (21) Frontal contusion 8 (19) None 6 (14) Pneumocephalus Other lesions (details available)
Paraclinical examinations, n (%)	35 (81) Computed tomography 1 (2) Transferrin test Other less frequent examinations
Surgical delay (days), mean±SD	5.6±1.9
Surgical delay (categorized), n (%)	≤7 days: 33 (77) >7 days: 10 (23)

SD: Standard deviation, GCS: Glasgow coma scale

Table 2: Outcome by treatment modality.

Outcome	Conservative (n=18) (%)	Surgical (n=25) (%)	Total (%)
No disability	10 (56)	16 (64)	26 (60)
Moderate disability	3 (17)	4 (16)	7 (16)
Severe disability	2 (11)	3 (12)	5 (12)
Mortality	3 (17)	3 (12)	6 (14)

Significance threshold: P-value=0.05

Dai *et al.* (2020)^[9] in the U.S., found falls and assaults as primary mechanisms, highlighting socioeconomic and infrastructural disparities. Limited access to care also affects treatment strategies.

Table 3: Log-rank comparison for mortality.

Group comparison	P-value	Interpretation
Conservative versus surgical	0.45	No significant difference
Fain-peri type I versus type III	0.002	Significantly higher mortality
GCS ≤8 versus GCS >12	<0.001	Significantly higher mortality

GCS: Glasgow coma scale, P-value Significant at: 0.05

Table 4: Multivariate analysis of factors of unfavorable outcome.

Predictor	adjusted hazard ratio	95% confidence interval	P-value	interpretation
Glasgow coma scale ≤8 (vs. 13–15)	4.5	1.8–11.2	0.001	350% increased hazard
Fain and Peri type III (vs. I)	3.8	1.5–9.6	0.005	280% increased hazard
Meningitis at admission	2.9	1.1–7.3	0.03	190% increased hazard
Surgical delay >7 days	2.3	0.9–5.8	0.08	NS after adjustment

The occupational profile of patients (44% manual laborers) parallels findings from South Africa, where Mokolane *et al.* (2019)^[3] identified construction and informal sector workers as high-risk groups for head injury. This emphasizes the intersection of occupational safety neglect and poverty in LICs. Delayed presentation owing to poor healthcare access remains a significant obstacle. A study in Uganda found that only 30% of TBI patients reached a hospital within the “golden hour,”^[10] compared to over 70% in many HICs.^[11] Such delays exacerbate complications such as CSF leaks and infections. Our findings confirm that ASBF disproportionately affects young people and are economically active. This aligns with studies from other African nations highlighting the severe socioeconomic impact of these injuries on families and communities.

The high prevalence of meningitis at admission (28%) contrasts sharply with HICs, where antibiotic prophylaxis reduces rates to <5%.^[12] This high rate of meningitis diagnosis and neurosurgical reference. In Nigeria, Ismail *et al.* (2020)^[13] observed a 24% meningitis rate in post-traumatic CSF leaks, attributing this to delayed antibiotic administration. The role of prophylactic antibiotics in the prevention of meningitis in patients with skull base fractures and CSF leaks remains controversial. One study conducted in Nigeria concluded that not using antibiotic prophylaxis does not lead to worse outcome scores in their developing country setting.^[8] This contrasts with the theoretical risk of infection associated with CSF leaks and the major trend toward antibiotic prophylaxis in developed countries.^[14] The conservative management strategy employed in our study reflects the resource constraints and mirroring practices in many LICs.

Pneumocephalus is a significant finding associated with ASBF, which creates communication between the cranial cavity and paranasal sinuses. CT is crucial for diagnosing pneumocephalus and identifying skull fractures.^[15]

The incidence of CSF leaks in our study was notably high, possibly because of delayed presentation and limited access to specialized care, with the nasal cavity being the most common site of leakage. This is consistent with findings in other studies that reported CSF rhinorrhea in a significant proportion of patients with ASBF.^[6] Our conservative approach to initial management, prioritizing observation and antibiotics, reflects resource constraints, but also aligns with evidence suggesting that many post-traumatic CSF leaks resolve spontaneously.^[16] However, the high rate of surgical intervention in our cohort underscores the need for improved diagnostic capabilities for the early identification and treatment of persistent leaks.

Surgical repair, when necessary, typically involves a multidisciplinary approach involving neurosurgery; Ear, Nose, and Throat; and maxillofacial surgery in collaboration to achieve watertight closure and prevent recurrent meningitis.^[17] The extended duration from injury to definitive treatment was not a statistically significant factor of mortality in our study, but likely contributed to higher complication rates, including infections and prolonged hospital stays. Furthermore, it is essential to recognize that diagnostic algorithms and general management principles are similar regardless of location; however, grouping skull base fractures under the umbrella term closed head injuries is misleading.^[18]

Moreover, variations in surgical techniques, dictated by available resources and expertise, may significantly influence patient outcomes, necessitating a focus on context-specific surgical training and the adaptation of best-practice guidelines to fit local realities.^[3,19] The differences in injury patterns and outcomes between our study and those from HICs underscore the need for tailored strategies to address specific challenges of neurotrauma care in resource-limited settings.^[20]

The correlation between low GCS (≤ 8) and mortality (HR = 4.5, $P = 0.001$) is consistent with Tanzanian data from Elahi *et al.* (2019), where GCS ≤ 8 increased mortality risk by 3.5-fold,^[21] highlighting the limited availability of advanced neuromonitoring in the neonatal ICU (NICU). Extended NICU stays also correlated with poorer outcomes, aligning with reports from Uganda, where limited ICU resources and high patient volumes hinder optimal care.^[20] The absence of formal trauma systems and protocols for pre-hospital care in our setting likely contributes to delays in treatment and poorer outcomes.^[22]

Guinea's reliance on craniotomy with duroplasty contrasts with HIC's preferences for endoscopic repair. In the U.S.,

Hegazy *et al.* (2000) demonstrated 95% success rates with endoscopic techniques and <5% sepsis, while Guinea's open surgeries, often delayed, incurred 24% sepsis rates.^[12] Similar challenges were noted in Nigeria, where Ismail *et al.* (2020)^[13] reported 20% of postoperative infections in craniotomies. The absence of specialized neurosurgical equipment, such as high-speed drills, can compromise the precision and safety of surgical interventions.^[23] These factors, combined with delayed presentation and limited access to post-operative care, contributed to the elevated complication rates observed in our study.

Guinea's 82% conservative success rate aligns with Hosameldin *et al.* (2019) in Egypt, where lumbar drainage achieved 85% resolution.^[24] However, Guinea's 18% failure rate necessitating delayed surgery exceeds HIC benchmarks, where early endoscopic intervention reduces reoperation needs.^[9] It is important to contextualize our study within Guinea's broader healthcare landscape, a nation of 13 million residents facing significant constraints in neurosurgical resources.^[25]

The connection between delayed surgery and infection (but not mortality after adjustment) is consistent with findings in Nigeria.^[26] Research in Ethiopia by Laeke *et al.* (2021) showed that waits longer than 72 h doubled the risk of complications, underscoring the need for efficient surgical processes in low-resource settings.^[20] In addition, managing ASBF in resource-constrained environments requires a practical approach, carefully balancing surgical treatment and conservative measures to minimize complications and optimize the use of available resources.^[27] Proponents of this view emphasize the need for context-specific and flexible treatment strategies that account for the unique challenges faced in low-resource settings.

According to the Fain and Peri classification, the mortality gradient across fracture types (7% for type I vs. 40% for type III) mirrors global trends. Bouchaouch *et al.* (2015).^[7] analyzed 136 ASBF in Morocco and reported that fractures involving the orbital roof (a subset of complex fractures) were associated with higher morbidity, including meningitis and pneumocephalus. While they did not explicitly quantify mortality for orbital fractures, they emphasized that fractures extending into the orbit or sphenoid sinus were correlated with worse outcomes. Similarly, Seok *et al.*, noted that fractures with orbital or sphenoid involvement had a 2.5-fold increased risk of complications (e.g., meningitis, sepsis) compared to unilateral fractures.^[16] This aligns with our study's finding of a 40% mortality rate for type III (orbital/sphenoid) fractures. For direct mortality comparisons, Elahi *et al.*^[21] reported a 28% mortality rate for severe TBIs involving skull base fractures, although orbital fractures were not isolated. Our study's high type I prevalence (70%) contrasts with HICs like Japan, where Shizawa *et al.* found

complex fractures (type II/III) in 40% of cases, likely due to differing injury mechanisms (e.g., falls vs. RTAs).^[28] Moreover, our 11.7% fatality rate for type III fractures exceeds HIC averages of 5–8%, reflecting local treatment barriers.^[20]

Although our study offers valuable insights, its results are limited by its retrospective design, which can introduce potential selection bias, a common issue in neurotrauma studies from LICs. Furthermore, the small sample size restricts our ability to conduct a thorough multivariate analysis of the confounding factors. In addition, the absence of beta-2 transferrin testing may have led to an underestimation of the prevalence of CSF leaks. Given that the study was conducted at a single Level I trauma center, the findings may not be fully generalizable to other settings in Guinea or West Africa. Future prospective, multicenter studies with larger sample sizes will be essential to validate these findings and establish more robust evidence-based guidelines for the management of ASBF in resource-limited environments.

Our data suggest the implementation of the following evidence-based solutions.

- Pre-hospital care: Enforce helmet laws, as advocated in the World Health Organization's 2018 Global Road Safety Report.^[29]
- Antibiotic protocols: Adopt Ethiopian models from Laeke *et al.* (2021), where IV ceftriaxone stockpiling reduced meningitis mortality by 30%.^[20]
- Endoscopic training: Per World Federation of Neurosurgical Societies guidelines, prioritize minimally invasive techniques to reduce sepsis, as shown by Sheth *et al.* (2022) in the U.S.^[2]
- Trauma Registries: Implement systems like those in Uganda, enabling real-time data analysis for resource allocation.^[10]

Integrating these measures with ongoing clinical audits, telemedicine consultations, and international collaborations could significantly enhance outcomes.^[30]

CONCLUSION

The management of ASBF with CSF leaks in Guinea reflects the systemic limitations pervasive across LICs. Although surgical intervention remains pivotal, outcomes are undermined by delayed care, limited diagnostics, and antibiotic shortages. Addressing these challenges requires prioritized funding for trauma systems, antibiotic access, and neurosurgical training of a roadmap supported by successful models in Nigeria and Ethiopia. In addition, multidisciplinary collaboration and the establishment of a trauma registry are essential for sustainable improvement.

Ethical approval: The research/study approved by the Institutional Review Board at Donka National Hospital's, number 0047, dated

2nd June 2025.

Declaration of patient consent: Patient's consent is not required as there are no patients in this study.

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