Mohamed *et al. Egyptian Journal of Neurosurgery* (2026) 41:77
https://doi.org/10.1186/s41984-025-00502-w

Egyptian Journal of Neurosurgery

RESEARCH **Open Access**

Prevalence and factors associated with cerebral spinal fluid leakage among patients with traumatic brain injury at Mbarara regional referral hospital, Western Uganda

Daud Abdirahman Mohamed[1,5*], Demoz Abraha[1,5], Safiriyu Abass[2,5], Mugenyi Michael[1,5], Sura Daniel[1,5], Bienfait Mumbere Vahwere[1,5], Franck Sikakulya[1,5], Maslah Osman[1,5], Yahye Osman[1,5], Abdulkadir Mohamed[1,5], Mohamed Abukar[1,5], Abdikani Ali[1,5], Adam Hassan[1,5], Mukhtar Mohamed[1,5], Abdifatah Abdi[1,5], Ismail Abdulkadir Ali[3,5], Theoneste Hakizimana[4,5], Ahmed Kiswezi[1,5], Abdullahi Ali Bulle[1,5] and Abdullahi Osman Abdulle[1]

Abstract

Background Globally, the annual rate of head injury is estimated to be 27 million, with developing countries seen to have a higher prevalence. In Uganda head injury mortality and complications have been reported to be high in different centres. The complications of cerebral spinal fluid (CSF) leakage could be contributing to the poor outcome, though no study in Uganda has assessed its burden. This study aimed to determine the prevalence and factors associated of CSF leakage among patients with traumatic brain injury (TBI) at Mbarara Regional Referral Hospital (MRRH).

Methods This was a sequential study at MRRH. All patients admitted with a diagnosis of TBI, irrespective of age or severity was included. Hallo test and Beta-transferrin test on Aural or nasal fluid were used for the diagnosis of CSF leakage. Logistic regression in SPSS version 26 was done to determine the significant factors. $P < 0.05$ was considered to be significant.

Results In this study, we enrolled 317 participants. Majority (78.5%) were aged between 19 and 59 years. Majority (83.0%) were male. CSF leakage was confirmed in 23, representing a prevalence of 7.3%. In the multivariable analysis, the independent factors associated with CSF leakage were: having RTA as the mechanism of injury (aOR = 3.521, CI = 1.162–9.671, $P = 0.002$), presenting with a Glasgow coma scale < 15 (aOR = 3.468, CI = 1.319–9.120, $P = 0.012$) and CT findings suggestive of skull fracture (aOR = 13.35, CI = 4.33–41.13, P = < 0.001).

*Correspondence:
Daud Abdirahman Mohamed
Mohamed.daud@studwc.kiu.ac.ug; drdauuud@gmail.com

Full list of author information is available at the end of the article

Conclusion The prevalence CSF leak among TBI patients was relatively high as it was seen in almost 1 patient in every 10 cases. All patients that present with features suggestive of CSF leak should undergo testing to confirm. Measures to minimize cases of assault as well as minimizing severe impact should be embarked on by the peace keepers, to minimize the cases of CSF leak, as they increase mortality and morbidity.

Keywords Prevalence, Cerebral spinal fluid leakage, Traumatic brian injury, Mbarara, Western Uganda

Introduction

Head injury is an important global public health concern and contributes to worldwide morbidity, mortality, disability and economic loss to the society more than any other traumatic insult [1–3]). A head injury often requires specialized neurosurgical care due to the vast range of anatomical and physiologic changes it causes. A physiological fluid called cerebrospinal fluid (CSF) keeps intracranial pressure (ICP) stable and protects the brain. It is made at the choroid plexus, where 140 mL of it is constantly flowing and being changed over. The breakdown of the meningeal structure following severe craniomaxillofacial trauma may cause a CSF leak from the subarachnoid area [4, 5].

Approximately 1·7 million TBIs occur in the USA alone each year, either as part of poly trauma or in isolation [3]. In South East Asia TBIs arising from road traffic accidents was highest (56% of cases) compared to only 25% cases in North America [1]. Both South East Asia and Europe have an almost similar incidence of Road traffic accidents with 1.5% to 1.2% respectively [1]. In sub-Saharan Africa, TBI is the major cause of morbidity and mortality [3],with the greatest percentage occurring in patients aged 19–40 years mainly affecting males [3].

Traumatic brain injuries have grave social and economic ramifications in addition to terrible physical and psychological effects on the patient. The commonest cause of TBI is motor vehicle accidents, followed by gunshot wounds and falls [6].

Several studies have described clinical and injury-related characteristics associated with its occurrence. In the United States, retrospective trauma registry data ($n = 4,986$) demonstrated higher CSF leak rates in penetrating injuries (4.9%) and motor vehicle accidents (1.8%) compared with blunt trauma (0.9%). Lower Glasgow Coma Scale (GCS) scores, LeFort type II/III and panfacial fractures, and radiographic midline shift were strongly associated with increased risk (Lucke-wold & Murad, 2022). A UK study similarly found that patients with CSF rhinorrhoea had a higher incidence of periorbital haematoma, suggesting its value as a clinical marker of underlying Dural tears (Choi & Spann, 1996). In Taiwan, a large series ($n = 1,323$) reported motor vehicle crashes—particularly motorcycle accidents—as the leading mechanism of CSF leakage, followed by falls and assaults (Chiu et al., 2010).

Although these studies highlight potential risk factors, most remain descriptive, with limited use of inferential statistics to quantify independent predictors. This study therefore aimed to investigate the demographic, clinical, and injury-related factors associated with CSF leakage.

Methodology

Study design and settings

This was a hospital based cross-sectional study design in which patients with TBI were enrolled and assessed for presence of CSF leakage and their associated factors at Mbarara regional referral hospital MRRH which is located in Mbarara city, in western Uganda, a public hospital about 271 km from Kampala. The hospital has a functional CT scan and a Radiologist and Radiology Department that guides in the interpretation of the CT images.

Study population

This study included all patients (adults and children) admitted with a diagnosis of traumatic brain injury including mild, moderate and severe traumatic brain injury. The study excluded patients who were admitted after 24 h following injury since in some patients the leakage can seal within 24 h, resulting in these patients being wrongly classified as without CSF leakage.

Sample size and sampling technique

For the prevalence, the sample size was calculated using Daniel's formula:

$$n = \frac{z^2 pq}{d^2}$$

Using findings by [7] in Kenya who reported that CSF leakage was seen in 25% of the patients with traumatic brain injury, $P = 0.25$, d = 0.05 and Z = 1.96 for 95% level of significance. Substituting, $n = 289$.

For associated factors, Epi-info online sample size calculator was used (https://www.openepi.com/SampleSize/SSCohort.htm). Using findings from a study by [8] who reported that CSF leakage was found in 8.8% of patients who had head injury in addition to maxillary fracture while it was found in only 0.9% of the participants who had head injury with mandible fractures, for a power of 80% and 95% level of confidence, the sample size required was 280 using Fleiss method.

Taking the bigger sample size (289) and adding 10% to increase internal validity, and cater for loss of follow up, the sample size required was 317.consecutive sampling method until the sample size was reached.

Data collection procedure

After obtaining consent, the principal investigator collected data by administering a structured questionnaire. All patients presenting with a history of head trauma were assessed using the ATLs protocol to confirm if they fulfilled the criteria for the diagnosis of traumatic brain injury with a severity of mild, moderate or severe. Those that satisfied the criteria were explained to the role of the study and asked to consent. If they fulfilled the inclusion criteria were included following informed consent. If the patient was awake, the following were checked for: a history of a salty postnasal drip; complaints of clear, watery discharge from the nose and ears; or discharge mixed with blood. CSF sample was collected and confirmation was done by testing aural or nasal fluid, using β-transferrin test when the CSF sample exceeded 2 mL, and the Halo test when the volume was less than 2mL.

Data analysis

Using SPSS version 26, the analysis was done.

For objective one; the percentage of TBI patients confirmed to have CSF leakage was computed as a fraction of all the study participants. The corresponding 95% confidence interval was reported.

For objective two, bivariate and multivariate analysis was done using logistic regression reporting both odd ratios and P values. Variables with P value ≤ 0.2 at bivariate were reanalysed at multivariate level. Variables with $P \leq 0.05$ were considered significant risk factors for CSF leakage in TBI.

Results

During the study period, 361 patients with traumatic brain injury presented to the study centre. 43 of these were not legible due to presenting after 24 h. Consent could not be obtained for 1. The remaining 317 were enrolled and followed up, with documentation of outcome.

Baseline characteristics of the study participants

In this study, we enrolled 317 participants. Majority (78.5%) were aged between 19 and 59 years. Majority of the participants (83.0%) were male. Over half of the participants (59.3%) were from rural areas. About 40% of the participants had a GCS < 15. Majority of the participants had mild injury according to the KTS (86.4%). In over 50% of the participants, the non-contrasted CT scan was unremarkable. The details are shown in Table 1 below.

Prevalence of CSF leakage among patients with TBI at MRRH

Of the 317 patients with traumatic brain injury that participated in this study, CSF leakage was confirmed in 23, representing a prevalence of 7.3%, with a 95% confidence interval of 4.7–10.1% as shown in Fig. 1 below.

Factors associated with CSF leakage among patients with TBI at MRRH

The variables considered for multivariate analysis ($P < 0.2$) were: age category, residence, mechanism of injury, Glasgow coma scale category, injury severity according to the KTS and findings on the non-contrasted CT scan as shown in Table 2 below.

In the multivariable analysis, the independent factors associated with CSF leakage among patients with TBI at MRRH were: having RTA as the mechanism of injury (aOR = 3.521, CI = 1.162–9.671, $P = 0.002$), presenting with a Glasgow coma scale < 15 (aOR = 3.468, CI = 1.319–9.120, $P = 0.012$) and CT findings suggestive of skull fracture (aOR = 13.35, CI = 4.330–7.41.13, P = < 0.001). The odds for CSF leakage among patients with TBI were increased by over 3 times for those who were due to RTA, by over 3 times for those who presented with a Glasgow coma scale < 15 and by over 10 times for those who had a fracture of the skull according to the CT scan. The details are shown in Table 3 below.

Discussion

This study was aimed at determining the prevalence, factors associated and outcomes of cerebral spinal fluid leakage among patients with traumatic brain injury at Mbarara Regional Referral Hospital. The interpretation of our findings, what they add to the current practice and comparisons with previously published data is detailed in the following subsections stratified according to the specific objectives.

Prevalence of CSF leakage among patients with TBI at MRRH

Of the 317 patients with traumatic brain injury that participated in this study, CSF leakage was confirmed in 23, representing a prevalence of 7.3%. This prevalence is relatively high.

According to [9], a lower GCS is associated with a more severe traumatic brain injury. That's to say GCS < 9 points to severe TBI where there is extensive brain damage and associated fractured skull which may include the base, sinuses and temporal lobes all of which are directly associated with CSF leak. A retrospective data was collected from a previously described trauma registry from 2010 to 2019. Patients over 18 years old with any type of facial fracture, known CSF leak status, available neuroimaging, and hospital admission were included, and it was

Table 1 Baseline characteristics of study participants

Characteristic	Frequency	Percentage
Age		
<18 (children)	46	14.5
19–59 (Adults)	249	78.5
60+ (elderly)	22	7
Sex		
Male	263	83.0
Female	54	17.0
Residence		
Urban	129	40.7
Rural	188	59.3
Mechanism		
Assault	97	30.6
Fall from height	45	14.2
RTA	175	55.2
Vomiting		
No	219	69.1
Yes	98	30.9
Seizures		
No	299	94.3
Yes	18	5.7
Lucid interval		
No	297	93.7
Yes	20	6.3
Smoking		
No	307	96.8
Yes	10	3.2
Alcohol		
No	254	80.1
Yes	63	19.9
Chronic illness		
No	307	96.8
Yes	10	3.2
Other Injury		
No	276	87.1
Yes	41	12.9
SPO2		
90+	288	90.9
<90	29	9.1
GCS		
15	189	59.6
<15	128	40.4
Pupil exam		
Normal	286	90.2
Abnormal	31	9.8
KTS		
Mild	274	86.4
Moderate	36	11.4
Severe	7	2.2
CT Findings		
Un remarkable	187	59.0
Hematoma/hemorrhage	89	28.1
Fracture	41	12.9

SPO2=peripheral oxygen saturation, GCS=Glasgow comma scale, KTS=Kampala trauma score, CT=Computed tomography

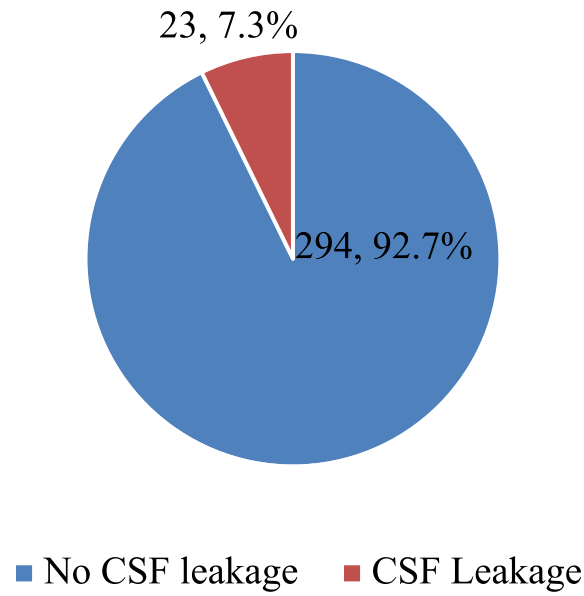

Fig. 1 Prevalence of CSF leakage among patients with TBI at MRRH. CSF = Cerebral spinal fluid

revealed that at the time of emergency medical services arrival, the Glasgow coma scale was significantly lower in patients with CSF leak compared to those without CSF leak (7.95 vs. 12.21). This is consistent with our findings where 40.4% of the study participants had GCS < 15.

Comparable to our findings, in the USA, one study that was profiling patient with traumatic brain injury reported that CSF leakage was seen in 9.43% of those with prolonged loss of consciousness [8]. Also comparable, a one-year descriptive case series was conducted in Pakistan from February 1, 2016, to January 31, 2017, at the Hayatabad Medical Complex in Peshawar, inside the Department of Neurosurgery. In order to identify the CSF leak, 422 patients who presented within 48 h of an acute head injury were included in a sequential fashion and monitored until the seventh day. In 5.2% of the patients, a CSF leak was found; a proportion falling within the confidence interval of our study findings [10].

Again comparable, a study was carried out in Pakistan from July 20, 2020, to January 20, 2021, at the Lady Reading Hospital's Neuro Surgery Department in Peshawar. The study comprised 303 patients who presented with acute head trauma within 24 h. The patients ranged in age from 18 to 65 years old and were of both genders. To confirm brain injury, a thorough history, clinical examination, and radiographic examination (CT and MRI) were performed on each patient. Sixteen participants in this study (5.3%) suffered CSF leaks [11] a proportion falling within the confidence interval of our study findings.

Contrary to our findings, a prospective cohort study was carried out in the Government Medical College's neurosurgery and general surgery ward in Kozhikode,

Table 2 Bivariate analysis of factors associated with CSF leakage among patients with TBI at MRRH

Characteristic	No CSF leakage, *N*=294	CSF leakage, *N*=23	Bivariate analysis		
			cOR	95% CI	*P* value
Age					
<18 (children)	45(15.3)	1(4.3)	Ref		
19–59 (Adults)	228(77.6)	21(91.3)	4.14	0.580–16.73.580.73	**0.176**
60+ (elderly)	21(7.1)	1(21.7)	2.140	0.17–12.55.17.55	0.450
Sex					
Male	245(83.3)	18(78.3)	Ref		
Female	49(16.7)	5(21.7)	1.389	0.492–3.918.492.918	0.535
Residence					
Urban	123(41.8)	6(26.1)	Ref		
Rural	171(58.2)	17(73.9)	2.038	0.781–5.318.781.318	**0.146**
Mechanism					
RTA	82(27.9)	15(65.2)	6.220	2.185–17.700.185.700	**0.001**
Fall from height	42(14.3)	3(13.0)	2.429	0.558–10.569.558.569	0.237
Assault	170(57.8)	5(21.7)	Ref		
Vomiting					
No	202(68.7)	17(73.9)	Ref		
Yes	92(31.3)	6(26.1)	0.775	0.296–2.030.296.030	0.604
Seizures					
No	277(94.2)	22(95.7)	Ref		
Yes	17(5.8)	1(4.3)	0.741	0.094–5.828.094.828	0.775
Lucid interval					
No	276(93.9)	21(91.3)	Ref		
Yes	18(6.1)	2(8.7)	1.460	0.317–6.722.317.722	0.627
Alcohol					
No	236(80.3)	18(78.3)	Ref		
Yes	58(19.7)	5(21.7)	1.130	0.403–3.171.403.171	0.816
Chronic illness					
No	285(96.9)	22(95.7)	Ref		
Yes	9(3.1)	1(4.3)	1.439	0.174–11.885.174.885	0.735
Other Injury					
No	256(87.1)	20(87.0)			
Yes	38(12.9)	3(13.0)	1.011	0.287–3.564.287.564	0.987
SPO2					
90+	267(90.8)	21(91.3)	Ref		
<90	27(9.2)	2(8.7)	0.942	0.209–4.235.209.235	0.938
GCS					
15	182(61.9)	7(30.4)	Ref		
<15	112(38.1)	16(69.6)	3.714	1.482–9.309.482.309	**0.005**
Pupil exam					
Normal	267(90.8)	19(82.6)	Ref		
Abnormal	27(9.2)	4(17.4)	2.082	0.660–6.566.660.566	0.211
KTS					
Mild	256(87.1)	18(78.3)	Ref		
Moderate	33(11.2)	3(13.0)	1.293	0.361–4.626.361.626	0.693
Severe	5(1.7)	2(8.7)	5.689	1.031–13.392.031.392	**0.046**
CT Findings					
Un remarkable	182(62.0)	5(21.8)	Ref		
Hematoma/haemorrhage	82(27.8)	7(30.4)	1.13	0.43–2.95.43.95	0.800
Base skull Fracture	30(10.2)	11(47.8)	8.06	3.19–20.35.19.35	**<0.001**

Bolded values were statistically significant in bivariate analysis since their *P* value was less than < 0.2

cOR = Crude odds ratio, CI = Confidence interval, SPO2 = peripheral oxygen saturation, GCS = Glasgow comma scale, KTS = Kampala trauma score, CT = Computed tomography

Table 3 Multivariable analysis of factors associated with CSF leakage among patients with TBI at MRRH

Characteristic	Bivariate analysis			Multivariate analysis		
	cOR	95% CI	*P* value	aOR	95% CI	*P* value
Age						
<18 (children)	Ref					
19–59 (Adults)	4.140	0.589–16.73.589.73	0.176	3.90	0.700–19.8.700.8	0.120
60+ (elderly)	2.14	1.440–21.661.440.661	0.530	2.11	0.20–15.5.20.5	0.4450
Residence						
Urban	Ref					
Rural	2.038	0.781–5.318.781.318	0.146	2.375	0.768–7.348.768.348	0.156
Mechanism						
RTA	**6.220**	**2.185–17.700.185.700**	**0.001**	**3.521**	**1.162–9.671.162.671**	**0.002**
Fall from height	2.429	0.558–10.569.558.569	0.237	2.712	0.791–12.414.791.414	0.242
Assault	Ref					
GCS						
15	Ref					
<15	**3.714**	**1.482–9.309.482.309**	**0.005**	**3.468**	**1.319–9.120.319.120**	**0.012**
KTS						
Mild	Ref					
Moderate	1.293	0.361–4.626.361.626	0.693	2.839	0.595–13.536.595.536	0.190
Severe	5.689	1.031–13.392.031.392	0.046	4.380	0.598–20.094.598.094	0.146
CT Findings						
Un remarkable	Ref					
Hematoma/hemorrhage	1.130	0.430–2.950.430.950	0.800	3.110	0.960–10.080.960.080	0.059
Base Skull racture	**8.60**	**3.190–20.35.190.35**	**<0.001**	**13.35**	**4.330–41.13.330.13**	**<0.001**

Bolded values were statistically significant $P \leq 0.05$ in multivariate analysis and were considered a significant risk factorof CSF leakage in traumatic brain injury patients

cOR = Crude odds ratio, aOR = adjusted odds ratio, CI = Confidence interval,

GCS = Glasgow comma scale, KTS = Kampala trauma score, CT = Computed tomography

Kerala, in India35 individuals (20.95%) out of the 167 total patients experienced a post-traumatic CSF leak. Six (17.14%) of these had CSF otorrhea, while 30 (85.71%) had CSF rhinorrhoea. In 18 patients (51.42%), the CSF leak lasted one day; in 10 patients (28.57%), it lasted two to ten days; and in 7 patients (20.00%), it lasted more than ten days). The percentages reported in this study were higher than those found in our study possibly because the inclusion criteria were limited to those with suspected CSF leak, as opposed to our study where all traumatic brain injury patients were included.

Again, contrary to our findings, in Ethiopia, an institutional-based cross-sectional study was conducted from January 1, 2018, to December 30, 2020. Of the total respondents with TBI, 91(18.8%) respondents had CSF otorrhea [12]. The presence of CSF was not confirmed by laparotomy measurement in this study since its primary objective was to assess mortality among patients with TBI, and it could have been the reason for the higher proportion reported.

Factors associated with CSF leakage among patients with TBI at MRRH

In the multivariable analysis, the independent factors associated with CSF leakage among patients with TBI at MRRH were: having RTA as the mechanism of injury, presenting with a Glasgow coma scale < 15 and CT findings suggestive of skull fracture. The odds for CSF leakage among patients with TBI were increased by over 3 times for those who had RTA, by over 3 times for those who presented with a Glasgow coma scale < 15 and by over 10 times for those who had a fracture of the skull according to the CT scan.

This study found that road traffic accidents (RTAs) were a significant factor associated with CSF leakage. This observation aligns with previous research, where RTAs have consistently been reported as the leading cause of traumatic CSF rhinorrhea and otorrhea [13]. documented RTAs as the predominant cause of post-traumatic CSF leaks, while [14, 15].

According to [9], a lower GCS is associated with a more severe traumatic brain injury. Retrospective data was collected from a previously described trauma registry from 2010 to 2019. Patients over 18 years old with any type of facial fracture, known CSF leak status, available neuroimaging, and hospital admission were included, and it was revealed that at the time of emergency medical services arrival, the Glasgow coma scale was significantly lower in patients with CSF leak compared to those without CSF leak (7.95 vs. 12.21). This is consistent with our findings where 69.6% of patients that had CSF leak had GCS < 15.

In agreement with our findings, a database of 4907 patients without CSF leak and 79 patients with CSF leak in the USA revealed that patients with lower Glasgow coma scores had higher rates of CSF leaks [8] In patients with documented facial fractures, CSF leak rates varied according to the mechanism of injury. Additionally, patients with a lower Glasgow coma scale, were more likely to experience CSF leaks [8].

According to [16], fractures particularly those involving the base of skull, create pathway to CSF leak out of the cranial cavity to the surrounding areas; nose, ears and sinuses by distracting the dura mater. The CT scan has the ability to reveal the extent, location and type of fracture [16]. A study by [17] that reviewed the medical records of 51 patients treated between 1984 and 1998, with CSF leaks that persisted for 24 h or longer after head trauma reported that forty-three (84%) patients with CSF leaks had an associated skull fracture, most commonly involving the frontal sinus [18]. This is consistent with our findings where 47.8% of the skull fractures had CSF leaks.

Study limitations

Single-Center Study: This research was conducted at Mbarara Regional Referral Hospital, limiting the generalizability of the findings to other regions or healthcare settings.

The beta-2 transferrin test was not performed for all patients, as a 2 ml sample could not be obtained in every case.

Conclusion

The prevalence CSF leak among TBI patients was relatively high as it was seen in almost 1 patient in every 10 cases.

The independent factors associated with CSF leakage among patients with TBI at MRRH were; having RTA as the mechanism of injury, presenting with a Glasgow coma scale < 15 and CT findings suggestive of skull fracture.

Abbreviations

LMICs	Low and middle-income countries
CSF	Cerebral spinal fluid
MRRH	Mbarara regional referral hospital
TBI	Traumatic brain injury
HI	Head injury
WHO	World health organization

Acknowledgements

Authors thank all the participants of the study and the nursing team of MRRH for the assistance provided during the data collection.

Author contributions

D.A.is the principal investigator, formulated the study, collected and analysed data and. D.A, S.A, M.M, and S.D, revised the methodology. B.M, F.S, M.O, Y.O, A.M, and M.A, designed the study and conceptualized. A.A, A.H, M.M, A.A, I.A, T.H, A.K, A.A, and A.O, designed the manuscript. All authors read and reviewed the manuscript.

Funding

This research was not funded by any specific grant from public or non-Profit organizations.

Data availability

Data can be obtained upon request; requests should be sent to drdauuud@gmail.com. Mohamed.daud@studwc.kiu.ac.ug.

Declarations

Ethical approval and consent to participate

Ethics approval and consent to participate of the study was approved by Kampala International University- Research ethics committee (Ref no: KIU-2024-698).

Consent for publication

Not applicable.

Competing of interest

The authors declare that they have no competing of interest.

Author details

[1]Department of Surgery, Faculty of clinical medicine and dentistry, Kampala international University Western campus, Ishaka Bushenyi, Uganda
[2]Department of physiology, Faculty of Biomedical sciences, Kampala international University Western campus, Ishaka Bushenyi, Uganda
[3]Department of Paediatrics and child health, Faculty of clinical medicine and dentistry, Kampala international University Western campus, Ishaka Bushenyi, Uganda
[4]Department of Obstetrics' and Gynaecology, Faculty of clinical medicine and dentistry, Kampala international University Western campus, Ishaka Bushenyi, Uganda
[5]school of Public health and Research, Somali National University, Mogadishu, Somalia

Received: 27 September 2025 / Accepted: 22 October 2025
Published online: 27 May 2026

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