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Survival analysis of time to decannulation and failure drivers among tracheostomy patients in Rwanda

Theogene Kubahoniyesu[1,2*] and Gadeline Tuyishime[3]

Abstract

Background Tracheostomy is essential for patients requiring prolonged ventilation, but studies on decannulation in Sub-Saharan Africa, including Rwanda, are limited. This study assesses decannulation success rates and identifying factors influencing the outcomes at the University Teaching Hospital of Kigali(CHUK).

Methods This was a retrospective cross-sectional study. Data on 62 patients who underwent tracheostomy at CHUK from October 2022 to October 2023 and reached decannulation were analyzed. Survival analysis was conducted using R, employing Kaplan-Meier (KM) curves to estimate median time to decannulation and Cox proportional hazards models to determine factors affecting outcomes. Bboth adjusted hazard ratio (AHR) and their confidence intervals (CI) were reported.

Results Decannulation failure observed from 22 patients (35.5%). The median time to decannulation was 60 days (Interquartile range (IQR): 46–74). KM indicated a shorter decannulation median time for elective tracheostomies (60 days, IQR: 43–77) compared to emergency ones (180 days, IQR: 151–209) and for females (60 days, IQR: 49–71) Compared to males (68 days, IQR:52–84). Elective tracheostomy was significantly associated with decannulation success, with an adjusted hazard ratio (AHR) of 0.19 (95% CI: 0.04–0.91, $P = 0.039$), indicating lower hazard for decannulation failure compared to emergency type. However, this finding is exploratory and should be interpreted cautiously. Age of a patient increased with less hazard to decannulation failure; however, the association was not statistically significant.

Conclusions Male Patients and those undergoing elective tracheostomies had a longer median time to decannulation. The findings highlight the importance of strategic planning in determining the timing and type of tracheostomy, with a focus on optimizing conditions for elective procedures whenever possible to improve patient outcomes.

Keywords Tracheostomy, Decannulation failure, Survival analysis, Rwanda

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Introduction

Tracheostomy is one of the most commonly performed procedures in critical care, significantly impacting clinical medicine by facilitating long-term ventilation and airway management for patients with severe respiratory conditions [1]. Globally, it is estimated that tracheostomy is performed in about 10 to15% of those who receive mechanical ventilation in intensive care units (ICUs) [2]. A study in United states,Spain, Bolivia, and Brazil [3] highlighted that the timing and outcomes of tracheostomy (typically within 7-10 days of mechanical ventilation) are associated with shorter ICU stays and improved survival rates. Moreover, a study in United Kingdom [4] reported the implementation of a guided quality improvement approach in tracheostomy, underscoring the effectiveness of multidisciplinary teamwork as advocated by the Global Tracheostomy Collaborative (GTC).

A tracheostomy is typically performed when patients require prolonged airway support that cannot be effectively managed by intubation alone. However, the indications extend beyond prolonged airway support. Tracheostomy may also be performed in emergency situations, such as when there is an acute upper airway obstruction due to trauma, tumors, or foreign bodies, or in cases of severe facial fractures or infections like epiglottitis that compromise airway patency. This procedure balances the risks associated with airway management, such as laryngotracheal injuries impacting speech, swallowing, and breathing, against potential benefits including improved patient comfort, facilitated rehabilitation, reduced sedation requirements, and minimized risk of quality-of-life impairments [5].

Once a tracheostomy is in place, the focus shifts towards managing the airway, preventing complications, and ultimately planning for decannulation. Decannulation is considered when a patient shows sufficient respiratory improvement and can maintain airway patency and protection independently. This process involves a multidisciplinary approach, incorporating assessments from respiratory therapists, speech and language therapists, and physiotherapists, among others, to ensure the patient is both physically and physiologically prepared for safe tube removal [5].

The timing of decannulation is a critical factor in the management of patients with tracheostomies and has significant implications for both short-term recovery and long-term outcomes [6]. Decannulation, the process of removing a tracheostomy tube once a patient no longer requires airway support, is considered a key indicator of recovery and progress in critical care settings [7].

In East Africa, the approach to tracheostomy differs markedly due to variations in resource availability, disease burdens, and access to specialized care. Unlike in more developed regions, tracheostomy in East Africa is often performed under emergency conditions, leading to a higher incidence of complications [8]. Emergency tracheostomies in African regions is three times more likely to result in adverse outcomes compared to their elective procedures [9]. At the University Teaching Hospital of Kigali (CHUK), the decannulation procedures follow a structured approach despite the limitations posed by resource constraints. A study in Spain [10] highlighted the effectiveness of high-flow oxygen therapy during decannulation. CHUK also utilizes this method when available, though the accessibility of high-flow oxygen equipment remains limited.

Despite the frequency of tracheostomy procedures in Rwanda, the timing of decannulation is crucial, as premature or delayed removal of the tracheostomy tube can lead to complications, increased healthcare costs, and prolonged hospital stays [5].

Recent studies, such as [11], which focus on tracheostomies in Rwanda, have highlighted that prolonged intubation is the most common indication for the procedure, accounting for 55.2% of cases. The study also reported a low incidence of post-operative complications, with 86.2% of patients being clinically stable after the procedure. However, outcomes in resource-constrained settings are highly variable, emphasizingthe need for more comprehensive data. Additionally, a study conducted in rural Kenya [12] found that the overall mortality rate for mechanically ventilated patients was 60.7%, demonstrating that models designed for high-resource settings often fail to predict mortality accurately in low-resource environments. This underscores the necessity for locally relevant research on patient outcomes, including the factors influencing successful decannulation after tracheostomy.

The primary objective of this study is to analyze the time to decannulation in Rwandan patients post-tracheostomy, using survival analysis to identify factors associated with decannulatiofailure. This insight enables healthcare providers to optimize care and improve outcomes for patients undergoing tracheostomy, ultimately contributing to better healthcare delivery and resource utilization in Rwanda's medical system.

General objective

The main objective of this research was to assess the time to decannulation and assess the drivers of tracheostomy failure.

Specific objectives

i. To determine the time to decannulation among tracheostomies in Rwanda.
ii. To identify the drivers of decannulation failure among tracheostomies in Rwanda.

Methods

Study design, setting and duration

This was a retrospective cross-sectional study involving patients who underwent tracheostomy at Kigali University Teaching Hhospital (CHUK). The patients who underwent permanent tracheostomy were excluded from the study, as this is a long-term or lifelong solution while temporary tracheostomy is typically performed with the intention of eventually removing the tracheostomy tube (decannulation). A total of 91 patients underwent temporary tracheostomy, of whom62 reached decannulation. The study analyzed the duration (in days) between tracheostomy and decannulation, as well as thefactors associated with decannulation outcomes.

Study setting

The study was conducted at Kigali university teaching hospital (CHUK: Centre Hospitalier Universtaire de Kigali), located in Capital city of Kigali, Rwanda. The hospital is renowned for surgical services including Otolaryngology (ENT), and ha specialized otolaryngologists [13]. The data were collected from patients during a period of one year, from October 2022 to October 2023.

Sample size determination

In this study, a formal sample size calculation was not conducted because the entire population of patients who underwent tracheostomy at Kigali University Teaching Hospital (CHUK) was included. A total of 62 patients met the inclusion criteria and were analyzed. This approach ensured that all data were captured, providing a comprehensive view of decannulation outcomes within the given time frame.

Data collection

Data were extracted from medical records of patients who underwent tracheostomy at Kigali University Teaching Hospital (CHUK). The information collected included patient demographics, the type of tracheostomy, and the timing of decannulation. The dependent variable was the outcome at the first decannulation attempt; if unsuccessful, the decannulation was considered a failure. Independent variables includedsocial demographic data (age, gender), indication for tracheostomy, type of tracheostomy (elective or emergency), duration of tran-laryngeal intubation before tracheostomy, duration of tracheostomy, decannulation outcome,cause of decannulation failure (if applicable) and o post-decannulation outcome. Decannulation success was defined as the removal of the tracheostomy tube without reintubation or replacement within 72 hours, while decannulation failure was defined as the need for reintubation, re-establishment of the tracheostomy, or significant respiratory distress requiring intervention within the same timeframe. Emergency tracheostomies were performed in situations where patients had acute upper airway obstruction. Common indications included trauma, infections (examples: Epiglottitis or abscesses), and tumors causing airway compromise. The patients were decannulated by surgeons from the respective departments that performed the tracheostomy. This included ENT specialists, general surgeons, and trauma physicians.

Table 1 Socio-demographic characteristics of patients who underwent decannulation

Characteristics	Frequency ($N=62$)	Percent (%)	Median time (days)
Age in years			
Mean ± Standard Deviation	39.7 ± 19.02		60
Gender			
Male	44	71	68
Female	18	29	60
Type of tracheostomy			
Elective	49	79	180
Emergency	13	21	60

Statistical analysis

Data entry was done using Kobo Toolbox. Data processing and statistical analyses was performed using R software. Survival analysis was employed to understand time to decannulation, and the log-rank test was used to identify the drivers of decannulation failure. Cox proportional hazard models were applied to estimate hazard ratios (HRs) with 95% confidence intervals (CIs), and a p-value below 5% was considered statistically significant. Potential confounders were controlled for by including clinical plausibility and previous literature to ensure that key factors influencing decannulation outcomes were accounted for.

Results

The analysis of 62 patients who reached decannulation indicated that the average age was 39.7 years. The gender breakdown showed that 44 patients (71%) were male and 18 patients (29%) were female. The majority of patients (79%) underwent elective tracheostomies. (Table 1)

Time to decannulation among patients who underwent tracheostomy

The analysis revealed that the median duration until decannulation was 60 days, with an interquatile range (IQR) of 46–74 days. This metric serves as an important marker for evaluating the temporal dynamics associated with decannulation outcomes in the participants.(Fig. 1).

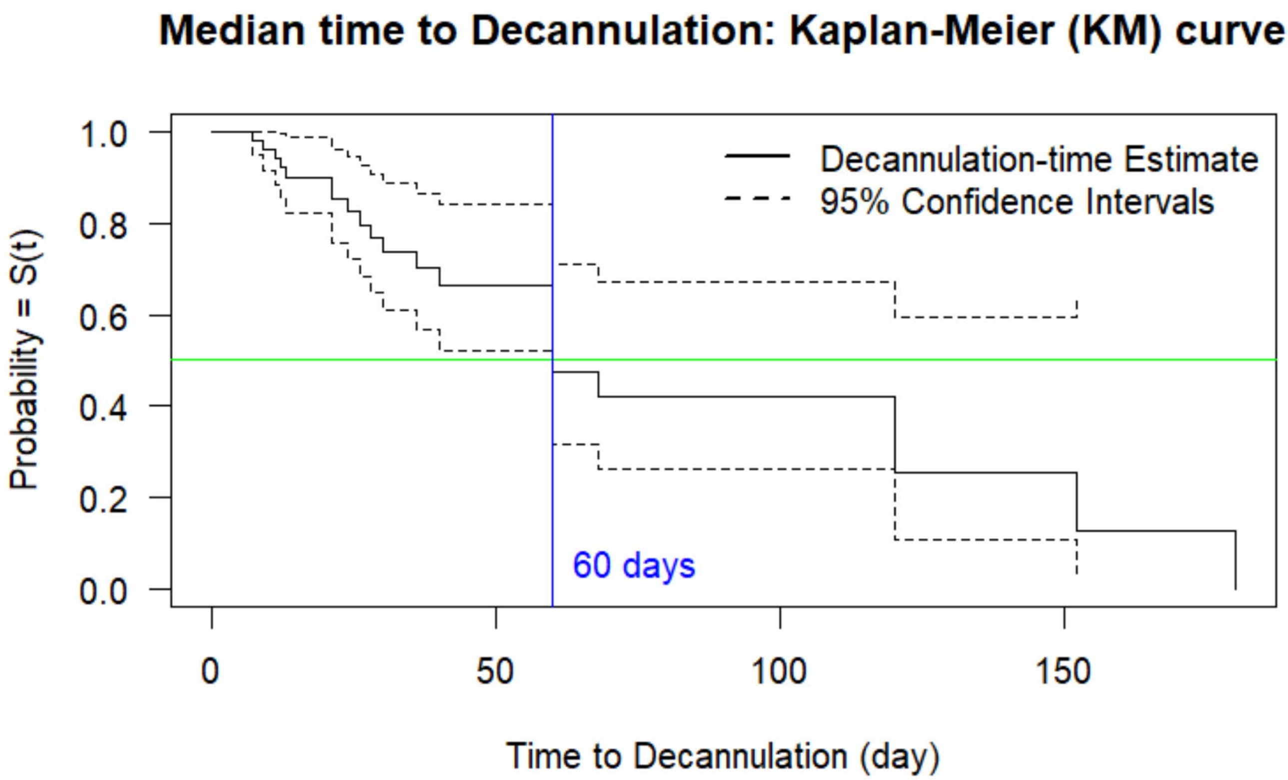

Fig. 1 Illustration of median time to decannulation

Time to decannulation among patients who underwent tracheostomy by gender

The results of the time to decannulation stratified by gender revealed a nuanced pattern, with males having a median time to decannulation of 68 days (IQR:52–84) and females having a slightly shorter median time to decannulation of (60 days, IQR: 49–71). This observed gender-based difference warrants further investigation into potential underlying factors. (Fig. 2)

Time to decannulation among patients who underwent tracheostomy by type of tracheostomy

The analysis of the time to decannulation stratified by tracheostomy type revealed that elective tracheostomies had a median time to decannulation of 60 days (IQR: 43–77) before decannulation failure, while emergency tracheostomies had a significantly longer median time to decannulation of 180 days (IQR: 151–209). The longer decannulation time for emergency tracheostomies likely reflects the urgency of the procedure and the severity of the patients' conditions, such as airways compromise due to trauma, infections, or other acute medical issues. (Fig. 3)

Factors associated with decannulation failure among patients who underwent tracheostomy

In this study, the association between tracheostomy outcomes and patient characteristics including age, gender, and tracheostomy type, was analyzed. Age was not found to significantly influence tracheostomy outcomes, with an adjusted hazard ratio (AHR) of 1.02 (95% CI: 0.95–1.24, $P = 0.09$). Similarly, gender differences did not significantly affect the success rates of tracheostomy, with males having an AHR of 0.58 (95% CI: 0.56–5.24, $P = 0.34$) compared to females. Notably, the type of tracheostoy performed was significantly associated with the outcome; elective tracheostomies resulted in a markedly lower risk of failure compared to emergency tracheostomies, with an AHR of 0.19 (95% CI: 0.04–0.91, $P = 0.039$). This suggests that elective tracheostomies are significantly more successful and carry a lower risk of failure than emergency procedures. (Table 2)

Discussion

This study found that the rate of decannulation failure is 35.5%, with factors such as the type of the tracheostomy procedure considerably influencing results, which is consistent with the findings of a study in United States [14] on pediatric tracheostomy decannulation failure. In contrast to the pediatric study's higher success rate (77.8% on the first attempt), the adult-focused study has a lower

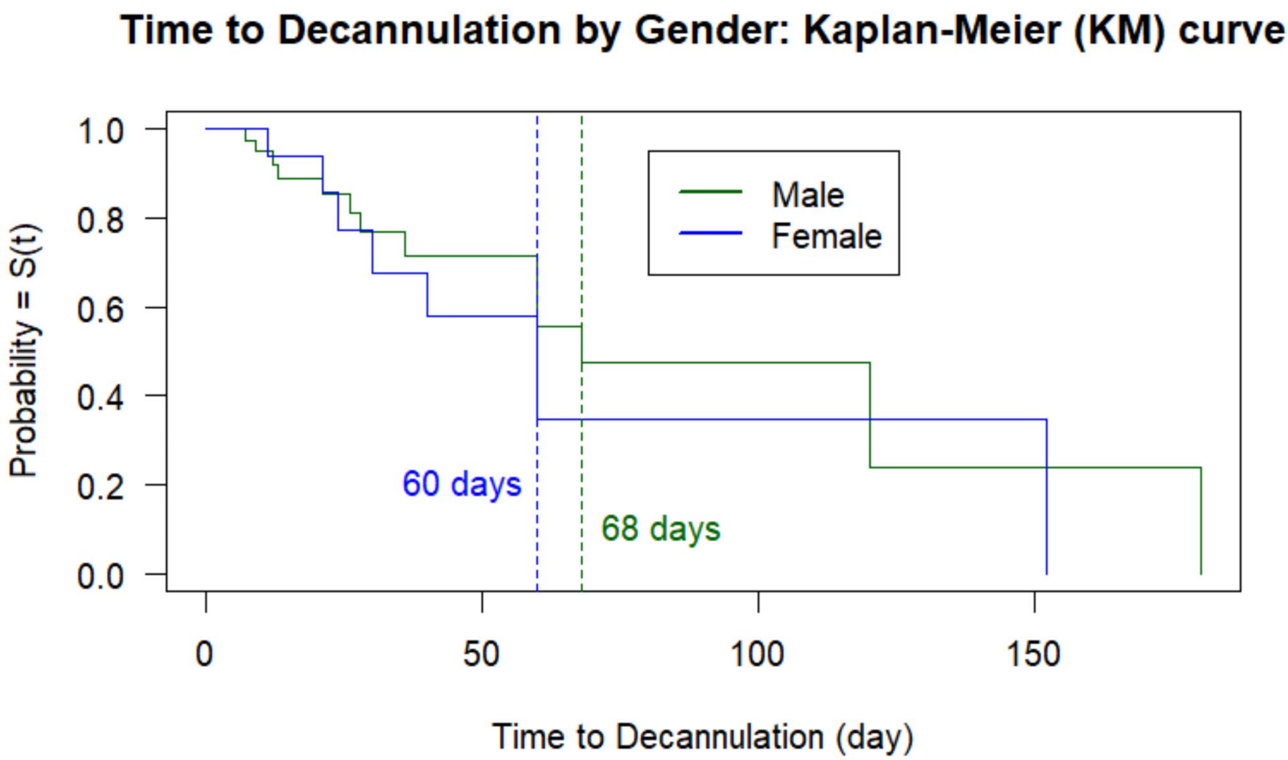

Fig. 2 Time to decannulation by gender

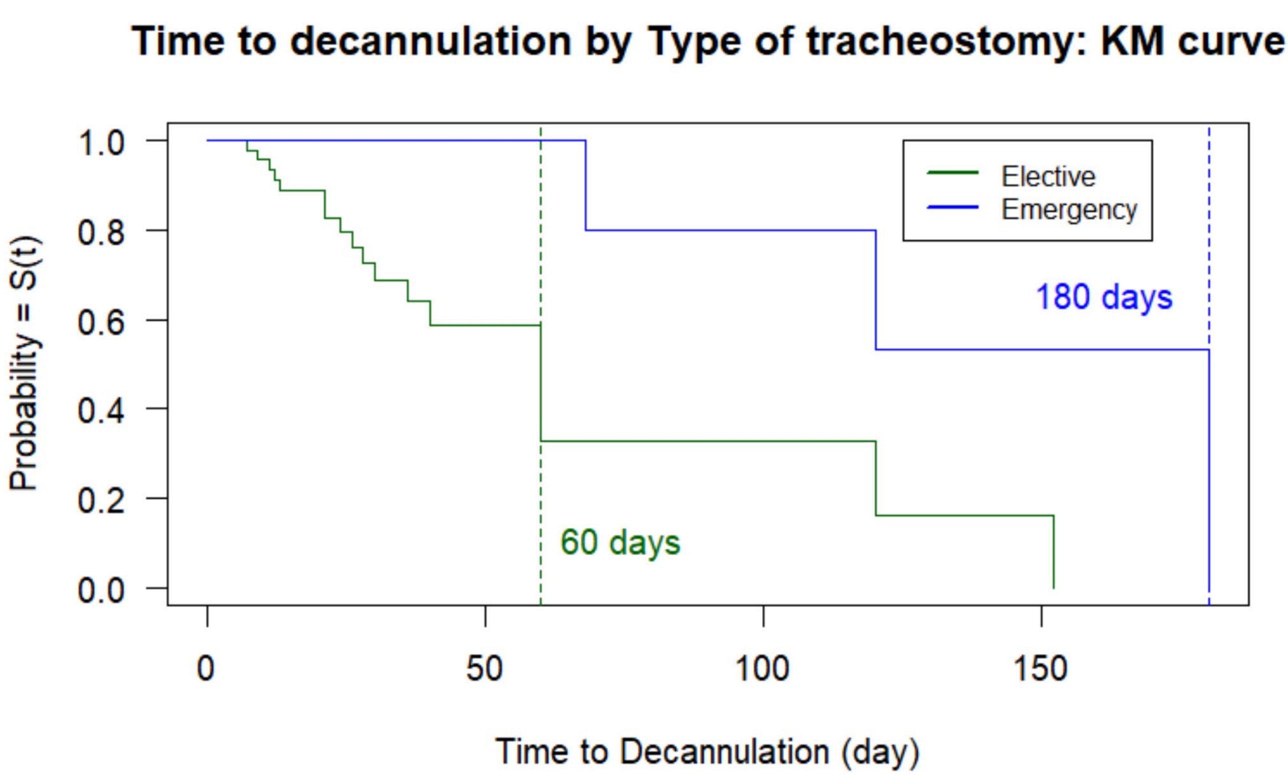

Fig. 3 Time to decannulation by type of tracheostomy. KM: Kaplan-Meier

Table 2 Factors associated with decannulation outcome. AHR: adjusted hazard ratio; CI: confidence interval

Characteristics	Failed *N* (%)	Succeeded *N* (%)	AHR	95% CI of AHR	*P*-value
Age	22 (35.5)	40 (64.5)	1.02	[0.95–1.24]	0.09
Gender					
Male	30 (68.2)	14 (31.8)	0.58	[0.56–5.24]	0.34
Female	10 (55.6)	8 (44.4)	*Ref		
Type of tracheostomy					
Elective	30 (61.2)	19 (38.8)	0.19	[0.04–0.91]	0.039
Emergency	10 (76.9)	3 (23.1)	*Ref		

**Ref*: Reference category

success rate, indicating potential disparities in patient groups and underlying factors impacting decannulation outcomes.

According to [15], a study that investigated the factors associated with pediatric tracheostomy decannulation failure in a single-institution context in Indiana, and found a greater initial decannulation success rate of 77.8% among pediatric patients. The pediatric study identified genetic abnormalities, eating dysfunction, and comorbidities as risk factors for decannulation failure, highlighting the significance of patient-specific variables in predicting outcomes.

Our research found that the median time to decannulation among adult patients undergoing tracheostomy in Rwanda is 60 days. This finding contrasts with a study [16], which focused on patients with severe traumatic brain injury (TBI) and found a median time to decannulation of 44 days. The variation in median decannulation times could be ascribed to variances in patient groups and underlying clinical conditions. However, both studies emphasize the necessity of identifying factors that influence decannulation results.

The previous study [17] found that older age (over 70 years), tracheostomies related to surgical operations, and being an ICU patient were independent predictors negatively associated with decannulation. Furthermore, they found a considerably greater 90-day mortality rate in patients who were not decannulated than in those who could be decannulated, demonstrating that decannulation may have an impact on patient outcomes.

This study's findings focus on adult patients undergoing tracheostomy in Rwanda, whereas the study [18] investigated the factors associated with with Bronchopulmonary Dysplasia (BPD). Amongsuccessful decannulated infants, the mean and median time to decannulation were 37.9 and 27.8 months, respectively. This significant disparity in decannulation times is most likely due to the diverse patient groups and underlying medical problems being evaluated.

This study reported a median time to decannulation of 60 days, whereas [19] found a median time of 37 days. This distinction is most likely due to variances in patient groups, underlying medical issues, and healthcare environments. Furthermore, while our study did not specifically look at characteristics like diabetes, craniotomy, and acute kidney injury (AKI) in relation to decannulation outcomes, the parallel found these conditions to be associated with it. Diabetes, craniotomy, and AKI were found to have an impact on the chance of successful decannulation, emphasizing the significance of taking comorbidities and medical history into account during the decannulation procedure.

The findings of this study have important implications,particularly in improving the management of tracheostomy patients in Rwanda and similar resource-limited settings. The association between elective tracheostomies and better outcomes suggests the need for early and strategic decision-making, which can be integrated into national healthcare protocols. Policymakers can use this evidence to promote training for healthcare providers and the development of guidelines that encourage timely elective tracheostomies, potentially reducing complications. Additionally, this research highlights the importance of robust data collection and monitoring to optimize patient outcomes, providing a foundation for refining clinical practices and resource allocation in critical care settings.

Study limitation

This study provides useful insights but has some limitations. The small sample size (62 patients) restricted statistical power and limit confounder analysis. The retrospective design limited the ability to establish temporal relationships and causality. Additionally, the single-center data from CHUK may not be generalizable to other settings. The abscence of detailed information on ICU indications, intubation duration, and severity of illness may have influenced decannulation outcomes but could not be fully analyzed.

Conclusions

The median time to decannulation for patients who underwent tracheostomy in Rwanda was 60 days. Factors such as the type of tracheostomy (elective vs. emergency) had a substantial impact on decannulation success, with elective procedures showing better outcomes. These findings underscore the importance of strategic planning in both the timing and management of tracheostomies to enhance patient outcomes. While elective tracheostomy is associated with better outcomes, it is likely that the underlying indications for elective procedures, often reflecting less severe or more stable clinical conditions, are the true predictors of favorable outcomes.

Abbreviations

AHR Adjusted Hazard Ratio
CHUK Kigali University Teaching Hospital
CI Confidence Interval
DHS Demographic and Health Surveys
ENT Ear, Nose, and Throat
GT Gadeline Tuyishime
ICU Intensive Care Unit
IQR Interquartile Range
KM Kaplan-Meier
SPSS Statistical Package for the Social Sciences
TBI Traumatic Brain Injury
TK Theogene Kubahoniyesu
WHO World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12893-025-02790-3.

Supplementary Material 1

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Author contributions
TK was responsible for the conception and design of the study, as well as data analysis and interpretation. GT provided administrative support, study materials, and patient data, in addition to overseeing data acquisition and organization. Both authors contributed to the manuscript and have given their final approval for submission.

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Data availability
The dataset analyzed during this study are patients' data available from the health facility (Kigali university teaching hospital), restrictions and data sharing policy may apply to be shared. The data are also available from the corresponding Author under reasonable request.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was carried out after approval given University Teaching Hospital of Kigali (CHUK) Ethics committee (Ref.:EC/CHUK/043/2023). Participants who were enrolled into the study have given their written informed consent. All data collected was treated with confidentiality and there was no addition cost to the patient.

Consent for publication
All authors have agreed to the order of authorship and to the publication of this work. Study participants provided consent for the scientific reporting of the study results. The manuscript does not contain any identifiable images or personal details of individual participants.

Competing interests
The authors declare no competing interests.

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