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Management and outcomes of esophageal atresia at a Kenyan tertiary hospital: A 13-year retrospective cohort study

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ABSTRACT

Introduction: Esophageal atresia (EA) is a congenital anomaly that causes a blind-ending esophagus with or without tracheoesophageal fistula (TEF). The global incidence ranges from 1:3500 to 1:4500 live births. In high-income countries, mortality rates have declined owing to advances in surgical expertise, neonatal care, and early diagnosis, although morbidity has increased. This improvement remains limited in low- and middle-income countries, where aspiration pneumonia and sepsis cause high mortality owing to delayed diagnosis, preoperative feeding, and poor referral systems. This study describes the management and outcomes of EA at Moi Teaching and Referral Hospital (MTRH) in Kenya.

Method: A 13-year retrospective cohort study was conducted by reviewing the medical records of patients managed for EA/TEF at MTRH from January 2010 to December 2022. These included demographic characteristics, pre- and postnatal details, clinical interventions, intraoperative findings, and postoperative outcomes.

Results: Among 67 patients with esophageal atresia, 64.2 % were male and 86.6 % were full-term. Cardiac anomalies occurred in 53.8 % of patients, most commonly patent ductus arteriosus, while non-cardiac anomalies were present in 19.4 %. The overall mortality was 44.8 %. Age at admission, birth weight, and surgical leaks did not significantly affect the outcomes. Sepsis was strongly associated with mortality (33.3 % in deaths vs. 5.4 % in survivors; $p < 0.001$). Patients who did not receive postoperative mechanical ventilation had higher adjusted odds of death (AOR 5.5, 95 % CI: 1.02–29.55, $p = 0.048$).

Conclusion: Pneumonia and sepsis remain the major contributors to mortality in this population. Improved referral pathways to reduce diagnostic delays and tailored postoperative ventilation strategies may enhance survival outcomes in patients with EA/TEF.

Introduction

Esophageal atresia (EA) is a rare congenital defect marked by incomplete development of the esophagus, resulting in a blind-ending esophagus that may or may not connect to the trachea. With an incidence of about 1 in 4099 births [1], EA poses significant challenges in neonatal care and pediatric surgery. While high-income countries report survival rates of 83–95 %, low- and middle-income countries (LMICs) encounter substantial difficulties in managing this condition, leading to poor outcomes and high mortality rates [2]. The etiology of EA remains unclear but is thought to be multifactorial, involving a complex interplay between genetic and environmental factors [3]. Associated anomalies are present in 46–60 % of EA cases, with cardiovascular, urogenital, and digestive system malformations being the most common

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[4]. The VACTERL association, which includes vertebral, anal, cardiac, tracheal-esophageal, renal, and limb anomalies, is frequently observed in patients with EA [5].

EA can be diagnosed prenatally or postnatally, and antenatal diagnosis rates have increased in recent decades [6]. Postnatal diagnosis is typically suspected based on presenting symptoms and is confirmed through the insertion of a large-caliber nasogastric tube [7]. Management of EA requires a multidisciplinary approach, including perioperative care and surgical intervention. However, the absence of standardized guidelines has led to variations in treatment approaches across institutions. Surgical management of EA primarily involves ligation of the tracheoesophageal fistula (TEF), if present, and anastomosis of the proximal and distal esophageal pouches [8]. The choice between open and thoracoscopic procedures depends on various factors, including the patient's condition and surgeon's expertise. Long-gap esophageal atresia presents additional challenges and may require specialized strategies to preserve the native esophagus [9].

EA repair outcomes have improved over time, particularly in high-income countries. However, complications such as anastomotic leaks, recurrent TEF, and anastomotic strictures remain significant concerns [10]. Esophageal dysmotility and gastroesophageal reflux are common long-term sequelae that require ongoing management [11]. Predictors of adverse outcomes in EA include low birth weight, associated anomalies (particularly cardiac malformations), delayed diagnosis, and type of EA. The Spitz classification and its subsequent modifications are valuable for assessing prognosis and guiding management decisions. Although significant progress has been made in understanding and treating esophageal atresia, challenges persist, especially in resource-limited settings [7,12]. This study describes the management and outcomes of EA at Moi Teaching and Referral Hospital (MTRH) in Kenya.

Method

Study design

This was a retrospective cohort study conducted from January 1, 2010, to December 31, 2022, at the Pediatric Surgery Department of Moi Teaching and Referral Hospital.

Study setting

MTRH is a tertiary teaching and referral hospital in Eldoret, Kenya. It is a metropolitan facility with a capacity of 1020 beds, including a 200-bed pediatric surgical department. Serving as the largest referral center in Western Kenya, MTRH provides both elective and emergency pediatric surgical care. The hospital draws patients primarily through referrals from the pediatric surgical outpatient clinic and the newborn unit.

Study population

All neonates diagnosed and managed with EA between January 2010 and December 2022 at MTRH.

Inclusion and exclusion criteria

Neonates managed for esophageal atresia at the Pediatric Surgery Department between January 1, 2010, and December 31, 2022, were included. Patients who underwent surgery at a different facility were also excluded.

Data collection

Data were extracted from patient hardcopy files and hospital registries and then entered into Redcap by trained research assistants. The Variables collected included sociodemographic data, pre- and postnatal characteristics (age at presentation, associated anomalies, and co-morbidities), clinical interventions, intraoperative details (type of surgery), and postoperative outcomes (complications, leaks, length of stay, and mortality).

Statistical analyses

Data were analyzed using the Stata Statistical Software Release 18 (StataCorp LLC, College Station, TX, USA). Patient demographics and clinical characteristics were summarized as frequencies and percentages for categorical variables. Survivors and non-survivors were compared using the Chi-square or Fisher's exact tests for categorical data, as appropriate. Univariate logistic regression was performed to identify factors associated with inpatient mortality. Due to the small sample size and quasi-complete separation in some predictors, multivariable analysis used Firth's penalized likelihood logistic regression via the 'firthlogit' command in Stata 18. This method reduces the small-sample bias and ensures model convergence when the standard maximum likelihood estimation fails. Variables with clinical relevance were included in a multivariate model. Odds (ORs), adjusted odds ratios (AORs), 95 % confidence intervals (CIs), and p-values were reported with significance set at $p < 0.05$. For temporal trend analysis, outcomes were additionally stratified by period of care (pre-2018 vs. 2018 onwards); the year 2018 was selected as the temporal cutoff because a dedicated neonatal intensive care unit (NICU) was established at our institution in that year.

Results

Patient demographic characteristics

A total of 67 patients with Esophageal Atresia were included in the study. The majority were male (64.2 %), with only one patient presenting with Disorders of Sex Development (DSD). The median gestational age was 38 weeks (range 29–41), with the majority of newborns delivered at term (≥36 weeks; 86.6 %) and 13.4 % classified as late preterm (28–35 weeks). The median birth weight was 2600 g (range 1600–3800). Among these, 43.3 % had a low birth weight (1500–2499 g), while 56.7 % had a normal birth weight (≥2500 g). More than half (53 %) of the patients were diagnosed within the first two days of life, whereas 24.2 % and 7.6 % were diagnosed between 3 and 6 days and 7–13 days, respectively. Age at admission, only 23.9 % of the patients were admitted within 0–2 days, with a significant number admitted later. Nearly all deliveries occurred in hospital settings (92.5 %), with spontaneous vaginal delivery (SVD) being the predominant mode of delivery (88.1 %) as provided in Table 1.

Clinical characteristics

At presentation, 24.2 % of the cases were hypothermic, 57.6 % had normal temperatures, and 18.2 % presented with fever. Most patients exhibited normal heart rates (93.4 %) and normal respiratory rates (77 %), whereas 23 % experienced respiratory distress (respiratory rate >60 breaths per minute). According to the Spitz classification, majority of patients were Group I (low risk) 86.6 % ($n = 58$), 11.9 % ($n = 8$) were in Group II (moderate risk), and 1.5 % ($n = 1$) in Group III (relatively high risk). Antenatal ultrasound findings were not universally indicated (Table 2). The most common presenting symptoms included feeding intolerance (37.3 %), inability to pass a nasogastric tube (25.4 %), choking (20.9 %), and frothing in the mouth (16.4 %). According to the ASA scores, the majority of patients were classified as ASA III (67.2 %) or ASA IV (25.4 %).

Preoperative interventions

Time to diagnosis (birth to diagnosis) was early (within 48 h) for

Table 1
Patient demographic characteristics.

Variable	n, %
Sex	
Male	43 (64.2)
Female	23 (34.3)
Intersex (DSD)	1 (1.5)
Gestational Age (weeks), median (min; max)	38 (29; 41)
Gestational Age (Weeks)	
Late Pre-term (28-35)	9 (13.4)
Term	58 (86.6)
Age category at diagnosis(n=66)	
0-2 days	35 (53.0)
3-6 days	16 (24.3)
7-13 days	5 (7.6)
14-20days	7 (10.6)
21-28 days	1 (1.5)
>1yrs	2 (3.0)
Age category at admission	
0-2 days	16 (23.9)
3-6 days	24 (35.8)
7-13 days	13 (19.4)
14-20days	8 (11.9)
21-28 days	2 (3.0)
>1yrs	4 (6.0)
Birth Weight (grams), median (min; max)	2600.0 (1600.0; 3800.0)
Birth Weight (grams)	
Low birth weight (1500-2499)	29 (43.3)
Normal (>2500)	38 (56.7)
Place of Delivery	
Home	5 (7.5)
Hospital	62 (92.5)
Type of Delivery	
SVD	59 (88.1)
Emergency CS	8 (11.9)

N=67, Age category at diagnosis(n=66,1 unknown)

Table 2
Clinical characteristics.

Variable	n, %
Body temperature	
Hypothermia (<36.5)	16 (24.2)
Normal	38 (57.6)
Fever (>37.5)	12 (18.2)
Heart rate	
Normal (70–190 beats/minute)	57 (93.4)
Tachycardia	4 (6.6)
Respiratory rate	
Normal (15–60 breaths/minute)	47 (77.0)
Respiratory distress (>60 breaths/minute)	14 (23.0)
Antenatal ultrasound done	
Not indicated	67 (100.0)
Presenting Symptoms	
Frothing from the mouth	11 (16.4)
Choking	14 (20.9)
Feeding intolerance	25 (37.3)
Inability to pass NGT	17 (25.4)
ASA Score	
II	3 (4.4)
III	45 (67.2)
IV	17 (25.4)
V	1 (1.5)
Not indicated	1 (1.5)
Spitz risk classification	
Group I (Low Risk)	58 (86.6)
Group II (Moderate Risk)	8 (11.9)
Group III (Relatively High Risk)	1 (1.5)

N=67, Body temperature (n=66, Not indicated=1), Heart rate (n=61, Not indicated=6), Respiratory rate (n=61, Not indicated=6), Spitz classification risk groups: Group I: No major cardiac anomalies, BW > 2000g, Group II: No major cardiac anomalies, BW < 2000g, Group III: Major cardiac anomalies, BW > 2000g and Group IV: Major cardiac anomalies, BW < 2000g

58.2 % ($n = 39$) of cases, while it was delayed (beyond 48 h) for 41.8 % ($n = 28$). Pneumonia was more prevalent in those with a delayed diagnosis compared to those diagnosed early (57.1 % vs. 38.5 %). The median time to definitive surgery was 72.0 h (range 12.0–408.0). Preoperatively, nearly all the patients (92.5 %) were referred from another facility. Upon arrival, 52.2 % of the patients had a nasogastric tube in place, and 92.5 % had an intravenous cannula. The majority were fed (74.6 %), and echocardiography was performed in 97 % of cases. Bronchoscopy was performed in only 28.4 % of cases as indicated in Table 3.

Cardiac anomalies in patients with esophageal atresia

Cardiac anomalies were present in over half of the patients (53.7 %). The most common finding was patent ductus arteriosus (PDA), either alone (16.4 %) or in combination with other defects. Complex anomalies included PDA with ventricular septal defects (VSD) (7.5 %), VSD alone (7.5 %), atrial septal defects (ASD) (4.5 %), and various combinations of multiple defects (Fig. 1). Notably, 46.2 % of patients had no detectable cardiac anomalies.

Associated non-cardiac anomalies

From Fig. 2, Most patients (80.6 %) had no associated non-cardiac anomalies. However, notable malformations included anorectal malformations (5.9 %), Down syndrome (3.0 %), a small number of cases with clubfoot (CTEV), disorders of sex development (DSD), cleft lip/palate, duodenal or jejunal/ileal atresia, and multiple syndromic anomalies.

Association between selected variables and mortality

The overall mortality rate was 44.8 % (Table 4). In bivariate analysis, mortality did not significantly vary by age at admission ($p = 0.29$), birth weight ($p = 0.32$), anastomotic leak ($p = 0.48$), associated anomalies ($p = 0.40$), Spitz classification ($p = 0.28$; 41.4 % Group I, 62.5 % Group II, 100 % Group III [$n = 1$]), long-gap atresia ($p = 0.91$), or surgical strategy ($p = 0.81$). Comorbidities differed significantly ($p < 0.001$): pneumonia was more common among survivors (62.2 % vs. 26.7 % non-survivors), while sepsis prevailed in non-survivors (33.3 % vs. 5.4 %). Mechanical ventilation showed higher mortality univariately ($p = 0.02$; 75.0 % with vs. 38.9 % without), despite greater use among survivors (91.7 % vs.

Table 3
Preoperative interventions.

Variable	n, %
Referral	
Yes	62 (92.5)
No	5 (7.5)
Time to diagnosis	
Early	39 (58.2)
Late	28 (41.8)
Time to definitive surgery (Hours), median (min; max)	72.0 (12.0; 408.0)
Nasogastric tube (NGT) in place on arrival	
Yes	35 (52.2)
No	32 (47.8)
IV cannula in place on arrival	
Yes	62 (92.5)
No	5 (7.5)
Baby fed	
Yes	50 (74.6)
No	15 (22.4)
Not indicated	2 (3.0)
ECHO done	
Yes	65 (97.0)
No	2 (3.0)
Bronchoscopy	
Not done	48 (71.6)
Not indicated	19 (28.4)

$N = 67$

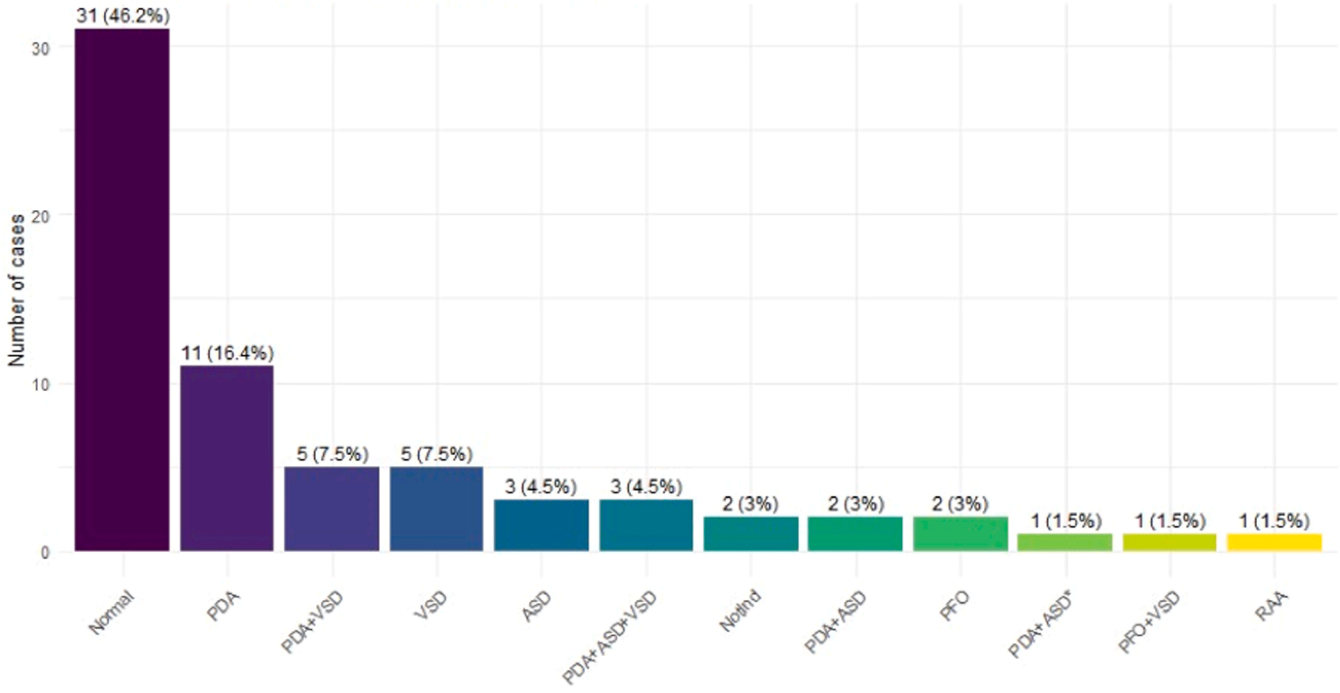

Fig. 1. Cardiac anomalies in EA/TEF patients.
PDA-Patent ductus arteriosus, VSD-Ventricular septal defect, ASD-Atrial septal defect, NotInd- Not indicated, PFO-Patent foramen ovale, RAA-Right sided aortic arch

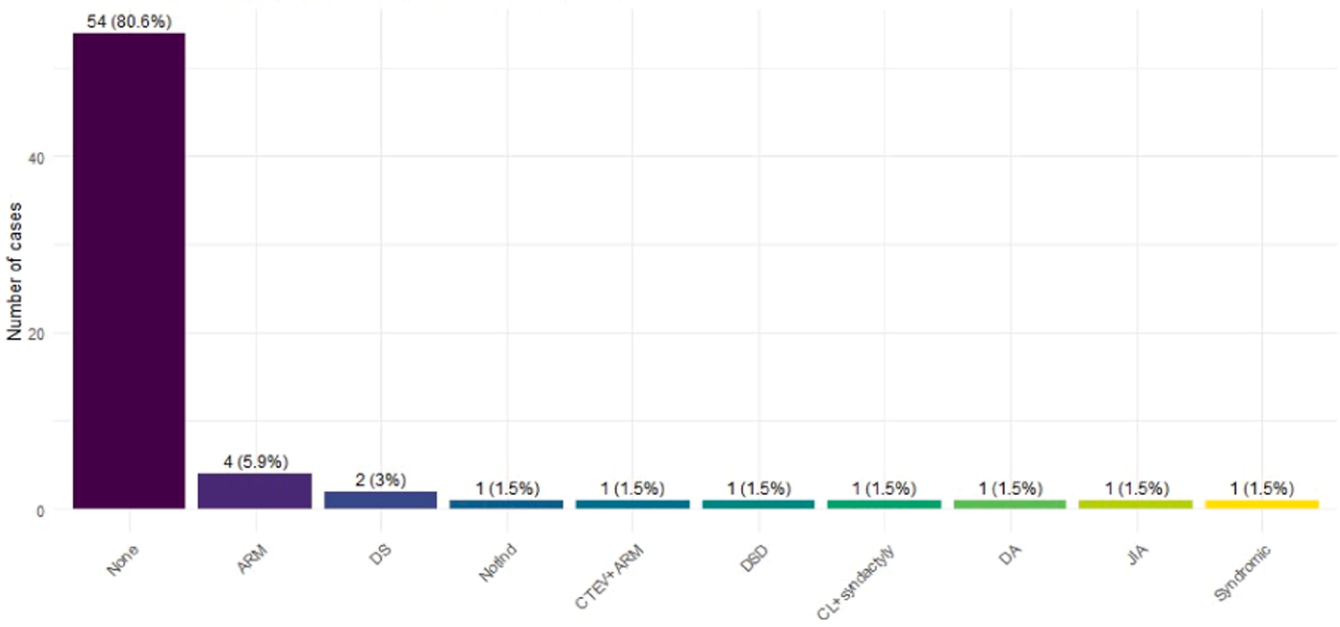

Fig. 2. Non-cardiac anomalies in EA/TEF patients.
None-no anomaly, ARM- Anorectal malformation, DS-Down syndrome, NotInd-Not indicated, CTEV+ARM-Clubfoot (CTEV), Anorectal malformation, DSD-Disorder of sexual development (DSD), CL+syndactyly-Cleft lip and palate, syndactyly, DA-Duodenal atresia, JIA-Jejunal ileal atresia, Syndromic- Syndromic (left renal agenesis, upper limb anomaly)

70.0 %).

Multivariate logistic regression of factors associated with mortality

Adjusted analyses using multivariate logistic regression identified the risk factors for mortality (Table 5). Compared to the reference group (0–2 days), other admission age categories showed no statistically significant increased risk (AOR for 3–6 days: 1.8, 95 % CI: 0.29–10.67, $p = 0.539$; 14–20 days: AOR 4.0, 95 % CI: 0.43–37.43, $p = 0.224$). Low birth weight was not significantly associated with mortality after adjustment (AOR 0.7, 95 % CI: 0.23–2.21, $p = 0.551$). Post-operative surgical leaks (AOR 1.4, 95 % CI: 0.25–7.72, $p = 0.713$), presence of major anomalies (AOR 1.5, 95 % CI: 0.35–6.12, $p = 0.607$), and comorbidities such as pneumonia (AOR 0.6, 95 % CI: 0.11–3.10, $p = 0.520$) and sepsis (AOR 4.5, 95 % CI: 0.40–49.38, $p = 0.222$) were also not statistically significant predictors. The only independent predictor of survival was use of

Table 4
Association between selected variables and mortality in patients with esophageal atresia.

Variable	Alive (n = 37,55.2 %)	Died(n = 30, 44.8)	Total (n, %)	P-value
Age category at admission				0.29
0–2 days	9 (24.3)	7 (23.3)	16 (23.9)	
3–6 days	12 (32.4)	12 (40.0)	24 (35.8)	
7–13 days	7 (18.9)	6 (20.0)	13 (19.4)	
14–20days	3 (8.1)	5 (16.7)	8 (11.9)	
21–28 days	2 (5.4)	0 (0.0)	2 (3.0)	
>1yrs	4 (10.8)	0 (0.0)	4 (6.0)	
Birth Weight (grams)				0.32
Low birth weight (1500–2499)	18 (48.6)	11 (36.7)	29 (43.3)	
Normal (>2500)	19 (51.4)	19 (63.3)	38 (56.7)	
Leaks				0.48
No	32 (86.5)	24 (80.0)	56 (83.6)	
Yes	5 (13.5)	6 (20.0)	11 (16.4)	
Associated anomalies				0.40
Normal	20 (54.1)	13 (43.3)	33 (49.3)	
Minor	10 (27.0)	7 (23.3)	17 (25.4)	
Major	7 (18.9)	10 (33.3)	17 (25.4)	
Spitz risk classification				0.28
Group I (Low Risk)	34 (91.9)	24 (80.0)	58 (86.6)	
Group II (Moderate Risk)	3 (8.1)	5 (16.7)	8 (11.9)	
Group III (Relatively High Risk)	0 (0.0)	1 (3.3)	1 (1.5)	
Presenting comorbidities				0.001
Pneumonia	23 (62.2)	8 (26.7)	31 (46.3)	
Sepsis	2 (5.4)	10 (33.3)	12 (17.9)	
None	12 (32.4)	12 (40.0)	24 (35.8)	
Long gap				0.91
No	30 (81.1)	24 (80.0)	54 (80.6)	
Yes	7 (18.9)	6 (20.0)	13 (19.4)	
Surgical strategy				0.81
Primary anastomosis	7 (18.9)	5 (16.7)	12 (17.9)	
Staged repair	30 (81.1)	25 (83.3)	55 (82.1)	
Mechanical Ventilation				0.02
Yes	3 (8.3)	9 (30.0)	12 (18.2)	
No	33 (91.7)	21 (70.0)	54 (81.8)	

N = 67 except for Mechanical Ventilation n = 66 with 1 not indicated, row percentages Totals in column percentage

mechanical ventilation after surgery, patients who did not receive mechanical ventilation had significantly higher adjusted odds of mortality (AOR 5.5, 95 % CI: 1.02–29.55, p = 0.048).

Discussion

Esophageal atresia is a relatively common congenital anomaly of the alimentary tract characterized by disruption of esophageal continuity and is often associated with tracheoesophageal fistulas. Exceptions include pure EA without a fistula and rare cases of fistula without atresia. This cohort comprised 17.9 % gross type A and 82.1 % gross type C cases, closely matching the typical global distribution of approximately 8–10 % for type A and 80–85 % for type C [13]. Similar distributions have been reported across Africa, with type C ranging from 80 % to 85 % [14]. The majority of EA/TEF patients managed at our center were referred neonates, predominantly term births, in hospital settings. Preterm infants accounted for only 13 %, which is lower than the 20–37 % preterm birth rate reported in global and African studies [15–17]. This discrepancy may be due to the unrecorded early mortality among preterm EA/TEF neonates who did not survive to reach tertiary care.

EA can be diagnosed prenatally or postnatally, and in this study, no cases were detected through prenatal ultrasound. This is consistent with established limitations, as routine prenatal ultrasounds accurately identify only about one-third of cases due to non-specific indicators, such as polyhydramnios and the absence of a stomach bubble [18,19]. In Europe, the rate of antenatal detection has risen to 36 %; however, the survival rates for isolated EA remain comparable, whether identified before or after birth, ranging from 93 % to 99 %. However, prenatally diagnosed cases may have a higher incidence of complications [6]. In our setting, the diagnosis was determined based on typical postnatal symptoms, including feeding intolerance (37 %), frothing (16 %), and coughing (14 %). Relying on feeding attempts and intolerance for diagnosis can result in dangerous delays, as observed in other low- and middle-income countries where late referrals and severe illness at presentation continue to be major challenges [20].

>50 % of our patients were diagnosed within the first two days after birth, yet only 23 % began treatment by the second day, which is significantly lower than the 83 % intervention rate within two days observed in high-income countries [21,22]. These delays might indicate a lack of suspicion and training in primary care facilities, highlighting the importance of targeted education to improve early detection and referral. Pneumonia and sepsis were common complications, with pneumonia identified in 62 % of those who survived and in 27 % of those who did not. Sepsis was a significant risk factor for death, occurring in 33 % of fatalities compared with 5 % of survivors. Frequent attempts to feed patients before diagnosis (74 %) likely played a role in these outcomes, aligning with Odera et al.'s South African data where up to 70 % of patients were diagnosed with aspiration pneumonia and sepsis [14].

Within our cohort, there was variability in the perioperative management. Although preoperative bronchoscopy, a routine procedure in numerous high-income countries, was not performed [23,24], echocardiography was performed in nearly all cases (97 %), and none of them showed right-sided aortic arches [14]. Cardiac anomalies were observed in 53.8 % of the cases, aligning with the 46–60 % range reported in international studies, with patent ductus arteriosus being the most frequent [25]. Non-cardiac anomalies were found in 19 % of patients, with anorectal malformations and sexual differentiation disorders being the most prevalent, consistent with the global literature [26,27]. Thoracotomy with esophageal anastomosis was the main surgical approach; patients with long-gap EA underwent gastrostomy and esophagostomy [28]. Postoperative feeding followed the published best practices, although the initiation times varied. Only 35 % of the patients experienced an uncomplicated postoperative course, with complications such as pneumonia, sepsis, and anastomotic leaks. The overall inpatient mortality rate was 44.8 %. Although this is lower than the 72 % reported in other sub-Saharan African studies [29], it remains substantially higher than the 1–9 % mortality rates commonly observed in high-income countries [23,30].

Several risk factors for adverse outcomes have been identified, including cardiac anomalies, low birth weight, concurrent anomalies, delayed diagnosis, and atresia type. Prognostic indices that incorporate these factors are frequently employed to inform preoperative counseling [17,31,32], and in line with findings from other African studies, our study revealed that the risk of mortality was higher for patients admitted between the third and sixth days of life than for those admitted earlier. Sepsis is associated with 4.5 times greater odds of death [17].

None of our cohort was intubated preoperatively despite the high ASA scores (ASA III/IV), even though they had high ASA scores (ASA III/IV). Notably, postoperative mechanical ventilation significantly improved survival (92 % of those ventilated survived compared with 70 % of those not ventilated). This finding aligns with studies indicating that elective postoperative ventilation can reduce the likelihood of anastomotic leaks, although the length of ventilation varies greatly among different settings [33,34]. The infrequent use of postoperative ventilation in this cohort likely reflects past limitations in the NICU capacity, especially before 2018, Mortality halved post-NICU, supporting resource investment.

Study strength and limitation

This study was limited by its retrospective design, which depended

Table 5
Multivariate logistic regression of factors associated with mortality in patients with esophageal atresia.

Variables	Cases	Died (n, %)		Unadjusted			Adjusted	
Age category at admission			OR	95 % CI	P value	OR	95 % CI	P value
0–2 days	16	7 (43.8)	ref			ref		
3–6 days	24	12 (50.0)	1.3	(0.37–4.37)	0.708	1.8	(0.29 - 10.67)	0.539
7–13 days	13	6 (46.2)	1.1	(0.27–4.55)	0.898	0.6	(0.05 - 6.81)	0.656
14–20	8	5 (62.5)	2	(0.38–10.33)	0.413	4	(0.43 - 37.43)	0.224
21–28 days	2	0 (0.0)	0.3	(0.01–6.11)	0.398	0.2	(0.01 - 6.96)	0.341
>1yrs	4	0 (0.0)	0.1	(0.01–3.05)	0.211	0.4	(0.01 - 12.24)	0.577
Birth Weight (grams)								
Normal (>2500)	38	19 (50.0)	ref				ref	
Low birth weight (1500–2499)	29	11 (37.9)	0.6	(0.24–1.64)	0.335	0.7	(0.23–2.21)	0.551
Leaks								
No	56	24 (42.9)	ref				ref	
Yes	11	6 (54.5)	1.6	(0.45–5.48)	0.481	1.4	(0.25–7.72)	0.713
Associated anomalies								
Normal	33	13 (39.4)	ref					
Minor	17	7 (41.2)	1.1	(0.34–3.47)	0.891	1.7	(0.32–8.77)	0.539
Major	17	10 (58.8)	2.1	(0.67–6.79)	0.203	1.5	(0.35–6.12)	0.607
Comorbidities								
None	24	12 (50.0)	ref					
Pneumonia	31	8 (25.8)	0.4	(0.12–1.10)	0.072	0.6	(0.11–3.10)	0.52
Sepsis	12	10 (83.3)	4.2	(0.86–20.52)	0.076	4.5	(0.40–49.38)	0.222
Long gap								
No	54	24 (44.4)	ref					
Yes	13	6 (46.2)	1.1	(0.33–3.50)	0.899	2.4	(0.47–12.36)	0.289
Mechanical Ventilation after surgery								
Yes	12	9 (75.0)	ref					
No	54	21 (38.9)	4.2	(1.11 - 16.15)	0.035	5.5	(1.02 - 29.55)	0.048

on the accuracy and completeness of medical records. Missing data, particularly from the early years of the review period, may have affected the identification of the anomalies and outcomes. The single-center setting and moderate sample size restricted the generalizability of the findings, while referral bias may have led to the underestimation of pre-hospital mortality and delayed cases. Additionally, the absence of routine prenatal screening and variations in perioperative management could have influenced both diagnosis and outcome measurements. Prospective multicenter studies are recommended to validate these findings and to further evaluate interventions aimed at improving EA/TEF outcomes in resource-limited settings.

Conclusion

Pneumonia and sepsis remain significant co-morbidities among patients with EA/TEF, substantially increasing the odds of mortality. Prenatal ultrasound diagnosis is rare, highlighting the missed opportunities for early detection. Most patients were referred from peripheral facilities with considerable delays in diagnosis and intervention. Strengthening referral systems and increasing clinician awareness may help reduce treatment delays and improve surgical outcomes of EA/TEF in resource-limited settings.

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Data confidentiality

De-identified data were extracted and stored in a secure Redcap project accessible only to authorized study personnel. All team members handling the data underwent data protection training and good clinical practice certification. Access to the original patient files and hospital registries was limited to research assistants and principal investigators.

Ethical considerations

Ethical approval for the use of these de-identified clinical data was granted by the Moi Teaching and Referral Hospital–Moi University Institutional Research and Ethics Committee (approval number 0004,524). The committee waived the requirement for individual informed consent, as the study involved a retrospective analysis of existing records without direct patient contact and posed minimal risk. All procedures adhered to the Declaration of Helsinki and complied with local regulations governing the use of routinely collected health data.

Data availability

Data are available from the corresponding author upon reasonable request.

Declaration of generative AI use

AI technologies were employed solely for grammatical correction and improving readability under the supervision of the authors.

CRediT authorship contribution statement

Vivian Cheboiwo: Writing – original draft, Resources, Methodology, Investigation, Funding acquisition, Conceptualization. **Moses Osoo:** Writing – review & editing, Formal analysis, Data curation. **Winfred Kimani:** Writing – review & editing, Project administration. **Abdiwahab Hussein:** Writing – review & editing, Data curation. **Brian Otieno:** Writing – review & editing, Data curation. **Tabitha Mirwoba:** Writing – review & editing, Data curation. **Nereah Aruwa:** Writing – review & editing, Data curation. **Michal Mbinji:** Writing – review & editing, Investigation. **Peter Saula:** Writing – review & editing, Supervision. **R Kuremu Tenge:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no financial or personal relationships (such as employment, consultancies, stock ownership,

honoraria, paid expert testimony, or patent applications/registrations) that could be viewed as potential competing interests in relation to this work.

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