ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCES

SCHOOL OF MEDICINE

DEPARTMENT OF PEDIATRICS AND CHILD HEALTH

MAGNITUDE AND PREDICTIVE FACTORS OF ACUTE MALNUTRITION IN CHILDREN WITH PATENT DUCTUS ARTERIOSUS AND SHORT-TERM POSTOPERATIVE NUTRITIONAL OUTCOMES AT TIKUR ANBESA SPECIALIZED HOSPITAL, ADDIS ABABA, ETHIOPIA:

A Hospital Based Cross Sectional Study

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Magnitude and Predictive Factors of Acute malnutrition in children with Patent Ductus Arteriosus and Short-Term Postoperative Nutritional Outcomes at Tikur Anbesa Specialized Hospital: A Hospital Based Cross-sectional Study

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Advisor's Approval Sheet

This is to certify that the thesis entitled "Magnitude and Predictive Factors of Acute malnutrition in children with Patent Ductus Arteriosus and Short-Term Postoperative Nutritional Outcomes at Tikur Anbesa Specialized Hospital: A Hospital Based Cross-sectional Study" is submitted in partial fulfillment of the requirements for the specialization certificate in pediatrics to Addis Abeba university college of health sciences, school of medicine, the department of pediatrics and child health, and has been carried out by Dr.Bereket Legesse under our supervision Therefore, we recommend that the student fulfill the requirements and, hence, submit the thesis to the department.

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Research Project Submission Template

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Name of Advisors	**Helen Mintesnot, MD Consultant Pediatrician and Pediatric cardiologist, Assistant Professor of Pediatrics and Child Health** **Signature:**
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List of Acronyms and Abbreviations

AOR: Adjusted Odds Ratio

BMI for age: body mass index for age

CHD: Congenital Heart Disease

CI: Confidence Interval

CHF: congestive heart failure

HAZ: Height-for-Age Z-score

HF: Heart failure

IYC: Infant and Young Child (Feeding)

LA:Ao: Left Atrium to Aorta (ratio)

MAM: Moderate Acute Malnutrition

MD: Doctor of Medicine

PDA: Patent Ductus Arteriosus

PHTN: pulmonary hypertension

SAM: Severe Acute Malnutrition

SD: Standard Deviation

SPSS: Statistical Package for Social Sciences

TASH: Tikur Anbessa Specialized Hospital

WAZ: Weight-for-Age Z-score

WHZ: Weight-for-Height Z-score

WHO: World Health Organization

Abstract

Background: Patent Ductus Arteriosus (PDA) is a common congenital heart defect that predisposes children to malnutrition due to increased metabolic demands and poor nutrient intake. In Ethiopia, the prevalence and predictors of malnutrition in children with specific defects like PDA, as well as their postoperative nutritional recovery, remain poorly characterized, hindering the development of targeted interventions.

Objectives: To assess the prevalence and predictive factors of malnutrition and determine the short-term postoperative nutritional outcomes among children with PDA at Tikur Anbessa Specialized Hospital (TASH).

Methods: A hospital-based comparative cross-sectional study was conducted at the pediatric cardiac clinic of TASH. A total of 87 children aged 1 month r=to 18 years who underwent surgical PDA correction in the past 3 years the latest being 3 months prior to the data collection were included. Data on demographics, clinical history, and PDA severity was collected via chart review. Preoperative and 3-month postoperative anthropometric measurements (weight and height/length) was converted into Z-scores (WAZ, HAZ, WHZ) using WHO standards (WHO Anthro Pluss application) to define malnutrition (wasting, stunting, underweight, over weight and obesity). Frequency and percent were used for categorical data and mean and SD was used to describe continuous data. Bivariate and multivariable logistic regression was used to identify predictive factors for acute malnutrition. Paired samples t-tests was used compared to pre- and post-operative Z-scores to assess nutritional recovery.

Result: A total of 87 children with PDA were included; the median age was 5years (IQR: -8), and 60 (69.0%) were female. Acute malnutrition was identified in 52 children (59.8%; 95% CI: 48.7-70.1). in multivariable analysis, female sex was associated with significantly lower odds of acute malnutrition (AOR= 0.33; 95% CI: 0.15-0.98; p=0.04), whereas the presence of other comorbidities was independently associated with higher odds of acute malnutrition (AOR= 10.2; 95% CI: 1.21-97.85; p=0.03).

Conclusion: This study reveals a high prevalence of preoperative malnutrition among children with Patent Ductus Arteriosus included in this study. The findings further demonstrate that the presence of additional comorbidities is a major contributor to poorer postoperative outcomes.

Most importantly, this research provides compelling evidence that surgical correction of PDA leads to a significant improvement in the nutritional status of these children, as assessed three months postoperatively. These results highlight the critical need for targeted nutritional interventions and comprehensive management of comorbidities to optimize surgical outcomes and support healthy growth in this vulnerable population.

Keywords: Patent Ductus Arteriosus, Malnutrition, Children, Postoperative Outcomes, Anthropometry, Ethiopia.

1. Introduction

1.1 Background

Patent Ductus Arteriosus (PDA) is a prevalent congenital heart defect defined by the persistence of fetal ductus arteriosus after birth, creating an aberrant vascular connection between the aorta and the pulmonary artery. This lesion facilitates significant left-to-right shunting of blood, resulting in pulmonary over circulation, volume overload, and a chronic state of elevated metabolic demand. Consequently, this pathophysiological state profoundly disrupts energy homeostasis and is a principal contributor to growth failure and malnutrition in afflicted infants and children (1).

Malnutrition represents a critical comorbidity in pediatric cardiology, characterized by imbalances in macro and micronutrient intake that severely compromise a child's developmental and health outcomes. Children with congenital heart disease (CHDs), such as PDA, are exceptionally vulnerable to undernutrition encompassing wasting, stunting and underweight due to the synegrgestic effects of increased caloric needs and decreased intake (1). This remains a pressing global health challenge; despite international efforts, undernutrition continues to affect approximately 150 million children under five years of age worldwide (2).

The magnitude of this problem is particularly severe within Ethiopia. Recent evidence indicates a disturbingly high prevalence of malnutrition among Ethiopian children with CHD, underscoring urgent public health crisis. One study reported that among children with CHD aged 1-12 months, 60.5% were underweight, 40.8% were stunted, and 52.6% exhibited wasting (3). This nutritional deficit is exacerbated by a constellation of factors, including pervasive poverty, food insecurity, suboptimal feeding practices, and limited access to specialized health care (2,4). Moreover, feeding practices play a critical role, as children who are breastfed on demand or introduced to complementary foods too early may experience inadequate nutritional intake (5). Furthermore, the severity of the cardiac lesion and the presence of comorbid conditions like anemia act as significant effect modifiers, further complicating the nutritional status of these children (6).

The preoperative nutritional status of a child with PDA is not merely a baseline measure but a pivotal prognostic indicator that significantly influences surgical outcomes. Malnourished children

endure a higher risk of postoperative complications, prolonged recovery times, and attenuated catch-up growth, thereby extending hospitalization and increasing healthcare costs(7). While international studies demonstrate that timely nutritional rehabilitation can markedly improve surgical recovery and long-term growth trajectories (8), the development of such effective, targeted in the Ethiopian context is hampered by a stark lack of localized evidence.

Therefore, this study addressed this critical knowledge gap by systematically investigating the magnitude and multifactorial predictors of malnutrition among children with PDA at Tikur Anbessa Specialized Hospital (TASH). Additionally, it evaluated the short-term postoperative nutritional outcomes following surgical correction. The findings from this research provide indispensable evidence to inform clinical management protocols, guide nutritional intervention strategies, and ultimately shape policy to improve the standard of care and health outcomes for this vulnerable pediatric population in Ethiopia(9,10).

1.2 Statement of the problem

Malnutrition is a critical complication among children with congenital heart disease (CHD), including those with Patent Ductus Arteriosus (PDA), and significantly impairs growth, development, and surgical outcome (3). Globally, malnutrition affects millions of children with CHD, with prevalence rates as high as 47% reported in Ethiopia(2,3). However, most studies focus broadly on CHD and do not disaggregate data by specific cardiac defects such as PDA, which may present unique nutritional challenges due to its pathophysiology and treatment course (9,10).

In Ethiopia, the nutritional status and postoperative recovery of children with PDA remain underexplored, particularly regarding short-term nutritional outcomes following surgical intervention at tertiary hospitals like Tikur Anbesa Specialized Hospital(11). Understanding the prevalence and predictive factors of malnutrition in this subgroup is essential, as malnutrition increases the risk of postoperative complications, delays recovery, and worsens prognosis (5,7). Despite evidence suggesting that timely nutritional rehabilitation improves outcomes(7,12), limited data exist on the postoperative nutritional trajectory of children with PDA in Ethiopia.

This gap hinders healthcare providers' ability to identify at-risk patients and tailor nutritional interventions effectively. Therefore, this study assessed the magnitude and predictive factors of

malnutrition, as well as short-term postoperative nutritional outcomes among children with PDA at Tikur Anbsesa Specialized Hospital, to inform clinical practice and improve patient care.

1.3 Significance of the study

In Ethiopia, the prevalence of malnutrition in children with Congenital heart disease (CHD) is alarmingly high, with studies indicating rates of undernutrition exceeding 60.5% (3). Understanding the magnitude and associated factors of malnutrition in this vulnerable population is essential for developing targeted interventions that can improve health outcomes.

The study focused on patients with Patent Ductus Arteriosus (PDA) undergoing surgical intervention at Tikur Anbessa Specialized Hospital (TASH). Specifically, the study investigated the prevalence of malnutrition among pre-operative PDA patients, providing clearer understanding of the magnitude of the problem in this population. In addition, the study shed the light on predictive factors influencing malnutrition, such as demographic status, preoperative comorbidities and complications, degree of pulmonary hypertension and age at surgery(6).

Furthermore, the study evaluated short-term postoperative nutritional outcomes following PDA closure. Short-term postoperative growth outcomes provided valuable insights into the effectiveness of surgical interventions and nutritional support in malnourished children with PDA. The research also improved understanding of nutritional recovery following surgery, which was crucial for optimizing care protocols in pediatric cardiac units (13).

Together, these findings underscored the importance of early nutritional assessment and management as an integral part of pre- and post-operative care. By addressing these factors, the study informed policy and clinical practice, ultimately contributing to the enhancement of the quality of life for affected children in Ethiopia (14).

2. Literature review

2.1 Definition of Malnutrition and Patent Ductus Arteriosus

Malnutrition encompasses deficiencies, excesses, or imbalances in nutrient intake, which can significantly affect health outcomes, particularly in vulnerable populations such as children. It includes undernutrition, characterized by stunting (low height for age), wasting (low weight fir height) and underweight (low weight for age), as well as overweight and obesity, which can lead to diet-related noncommunicable diseases (1). In pediatric populations, malnutrition is a critical concern as it adversely affects growth, cognitive development, and overall health, increasing the risk of morbidity and mortality(15).

Patent Ductus Arteriosus (PDA) is a congenital heart defect where the ductus arteriosus, a blood vessel connecting the pulmonary artery to aorta, fails to close after birth (1).

2.2 Magnitude of Malnutrition in children with congenital heart disease

Research indicates that malnutrition is a prevalent issue among children diagnosed with congenital heart disease (CHD). Woldesenbet et al. (2021) found that approximately 47% of children with congenital heart disease (CHD) in their study sample were malnourished. This study highlighted that $$% were underweight, while 29.7% were stunted. These findings reflect the severe impact of congenital heart disease (CHD) on nutritional status of affected children, showing that malnutrition is not only common but also multifaceted, affecting various aspects of growth (3).

Similarly, Asrade et at. (2021) reported significant rates of undernutrition in children with cardiac diseases, emphasizing that malnutrition is a critical concern that complicates medical management and increases morbidity (2). Their findings suggest that the prevalence of malnutrition is linked to factors such as socioeconomic status, feeding practices, and access to healthcare.

In a broader context, the magnitude of malnutrition in these demographic underscores the urgent need for targeted nutritional interventions. Studies suggest that early identification and management of malnutrition can significantly improve health outcomes and quality of life for children with CHD, reinforcing the importance of comprehensive care that includes nutritional support (4).

In Ethiopia, the situation is particularly dire, with malnutrition rates aming children with CHD being among the highest globally. Assefa et al. (2020) highlighted that severe acute malnutrition among Ethiopian children with CHD represents a critical public health challenge that demands immediate attention (5). The interplay of poverty, inadequate healthcare access, and lack of nutritional knowledge contributes to the high prevalence of malnutrition in this population, necessitating targeted interventions to improve health outcomes.

2.3 Predictive factors of Malnutrition in children with congenital heart disease

Several predictive factors contribute to the high rates of malnutrition among children with congenital heart diseases. Socioeconomic status is a primary determinant, as families with lower income levels often lack access to nutritious food options. Woldesenbet et al. (2021) found that malnutrition was significantly higher in children from low-income households (3). Additionally, feeding practices, including breastfeeding frequency and the timing of complementary feeding play crucial roles in determining nutritional status. Children who are breastfed irregularly or who receive early complementary foods are at increased risk of malnutrition (2).

Other predictive factors include the presence of comorbidities such as anemia, which often coexists with malnutrition in children with CHD. Studies have demonstrated that anemia exacerbates nutritional deficiencies and complicates the management of malnutrition (4). Furthermore, healthcare access is a vital determinant; children with limited access to specialized are may miss essential nutritional assessments and interventions, leading to poorer health outcomes (9).

2.4 Short term postoperative nutritional outcomes

Based on two studies of Thai children with congenital heart disease (CHD), cardiac surgery had a significant positive impact on malnutrition. In the study by sethasathien et al. (2022), wasted children under five showed significant improvement in weight-for-height Z-scores (WHZ) just two weeks after surgery (median WHZ improved from -2.82 SD to -1.76 SD, $p<0.001$) (16).

Similarly, Ratanachu-ek and pongdara (2011) found that the prevalence of wasting decreased dramatically from 22% preoperatively to 6% postoperatively ($p<0.05$), and the mean Z-scores for weight-for-age and weight-for-height increased significantly at all follow-up points ($p<0.001$) (8). These results demonstrate the surgical correction is a crucial intervention for mitigating acute malnutrition and promoting rapid catch-up growth in this vulnerable population.

Postoperative recovery in children with congenital heart disease is often complicated by preexisting malnutrition. Studies indicate that malnourished children experience slower recovery rates and poorer growth outcomes following cardiac surgery. Vaidyanathan et al. (2008) reported that malnutrition significantly impairs postoperative recovery and weight gain, highlighting the critical need for preoperative nutritional assessments and intervention (7). Additionally, De Souza et al. found that the nutritional recovery post-surgery can be significantly improved through targeted interventions, emphasizing the importance of addressing malnutrition before and after surgical procedures (14).

2.5 Policy implications and future directions

Addressing malnutrition in children with congenital heart disease requires a multifaceted approach, including policy changes that prioritize nutrition as a critical aspect of pediatric healthcare. Public health interventions should focus on educating families about proper feeding practices and the importance of nutrition in managing congenital heart diseases (5). Additionally, research should continue to explore effective strategies for combating malnutrition in this population.

3. Conceptual Framework

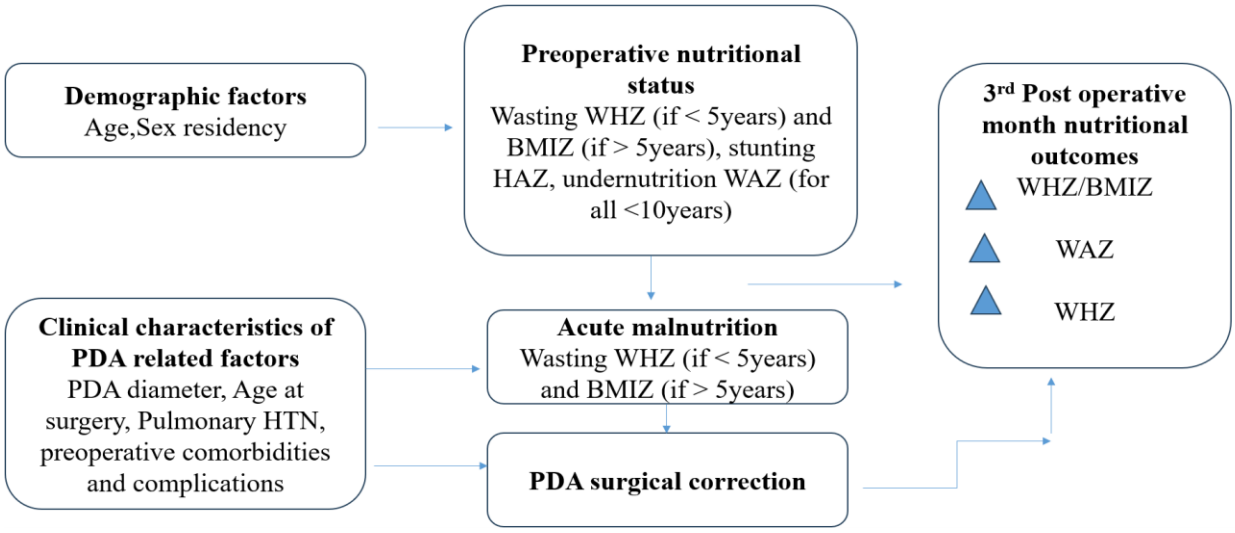


Figure 1. Conceptual framework.

4. Objectives

4.1 General Objectives

- To assess the prevalence and predictive factors of malnutrition and its short-term postoperative nutritional outcomes among children with Patent Ductus Arteriosus (PDA) at Tikur Anbessa Specialized Hospital (TASH), Addis Ababa, Ethiopia from September 11,2022 to August 30, 2024 GC.

4.2 Specific Objectives

- To determine the prevalence of malnutrition (wasting, stunting and underweight) among children with Patent Ductus Arteriosus (PDA) at Tikur Anbessa Specialized Hospital (TASH).
- To identify the predictive factors (demographic and clinical) associated with acute malnutrition (wasting) in children with Patent Ductus Arteriosus (PDA) at Tikur Anbessa Specialized Hospital (TASH).
- To assess the short-term postoperative nutritional outcomes by comparing the preoperative and 3-month postoperative anthropometric Z-scores (EAZ, HAZ,WHZ) in children who have undergone Patent Ductus Arteriosus (PDA) surgical correction.

5 Methods and Materials

5.1 Study area and period

The study was conducted at Tikur Anbessa Specialized Hospital (TASH) Pediatrics Cardiac Clinic, Addis Ababa Ethiopia from September 30, 2025 to December 1, 2025 GC.

Tikur Anbessa Hospital, which is a prominent specialized hospital located in Addis Ababa, Ethiopia. Established in 1964, it serves as a major teaching hospital affiliated with the School of Medicine at Addis Ababa University. The hospital provides a wide range of specialized clinical services and is a key training center for medical students and health professionals from Ethiopia and other African nations. With a diverse team of over 200 doctors, 379 nurses, and 115 other health professionals, supported by a total of 950 administrative staff. TASH is a cornerstone of healthcare in the region, delivering specialized medical services to patients hailing from every corner of the nation. Since its establishment in 1964, the hospital has grown to serve approximately

500,000 outpatients and more than 21,000 inpatients annually, making it the largest referral hospital in Ethiopia.

The pediatrics cardiac clinic works 5 times per week around 40-50 patients are seen per day on average. The clinic is mainly run by cardiologists, cardiology fellows, residents and nurses.

5.2 study design

- Hospital based cross-sectional study was conducted.

5.3 Population

5.3.1 Source population

- All pediatric patients with Patent Ductus Arteriosus (PDA) disease who have follow up at pediatrics cardiac clinic at Tikur Anbessa Specialized Hospital (TASH).

5.3.2 Study population

- All pediatrics postoperative Patent Ductus Arteriosus (PDA) patient who have follow up at pediatrics cardiac clinic at TASG from September 11,2022 to August 30, 2024 GC.

5.4 Eligibility

5.4.1 Inclusion criteria

- Children from 1 month to 18 years old operated PDA patinets
- Postoperative PDA patients whose surgery done 3 months prior to data collection date on follow up at TASH, pediatrics cardiac clinic.

5.4.2 Exclusion criteria

- Incomplete anthropometric data on the chart
- Those patients with other associated congenital heart disease.
- Children with other major syndromic conditions known to affect growth (e.g., Down syndrome).

5.5 Sample size determination and sampling technique

5.5.1 Sample size determination

- Sample size was determined using single population proportion formula considering confidence level of 95%, marginal error of 5% and proportion of 43.1%, taken from a study done on previously (3).

$$n = \frac{p(1-p)\left(Z_{\frac{\alpha}{2}}\right)^2}{d^2}$$

Where:

n= Required sample size

P= Proportion of children with Congenital Heart Disease (CHD)

Q = 1-p = Desired degree of precision (5%)

Z = The standard normal value at 95% confidence level

$$n = \frac{(1.96)^2 \times 0.43\ (1-0.43)}{0.05^2} = 377$$

Adding the expected incomplete data in 10% of the cases, the sample size became 429 patients. But, since the estimated total populations in the study area during the study period were less than 10,000, the following correction formula was used a finite population formula.

Formula:

$$n_f = \frac{n}{1 + \frac{n-1}{N}}$$

Where:

Nf- adjusted sample size after applying finite population correction.

n-initial sample size (before correction) including incomplete data. In this case 419 patients.

N- total population size = 117 (total number of postoperative PDA patients treated at cardiac Intensive Care Unit (ICU) in the past 3 years)

Using the above formula, the corrected sample size (nf) became 91 participants.

For this study, 87 patients were included which is 95.6% of the sample size.

5.6 Data collection tool and procedures

A structured questionnaire was developed by the principal investigator by adapting questions and constructs from previously validated tools. The demographic section was informed by instruments used in similar local studies on child health (3,11), while the clinical history sections were informed by relevant pediatric cardiology literature (3,17).

Data was collected using the following approaches. Medical chart abstraction was conducted by trained data collectors to obtain documented demographic information of the child. A comprehensive review of each participant's medical records was performed to retrieve information on medical history, preoperative nutritional status, surgical details, and postoperative nutritional status. Postoperative nutritional status was assessed during follow-up visits at the third postoperative month (8).

Anthropometric data, including weight and height, were extracted from participant's medical charts. These measurements were recorded preoperatively and at the third postoperative month. All anthropometric measurements (weight and height/length) were converted into Z-scores. Weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ) as well as body mass indes (BMI)-for-age using the World Health Organization (WHO) child growth standards (Anthro plus App) (18) to determine the nutritional status.

Data collection was carried out by trained health professionals and was closely supervised by the principal investigator.

5.7 Data quality control and management

The questionnaire was pretested on a sample equivalent to 5% of the calculated sample size at a different study site to assess clarity, validity and consistency. Based on the pretest findings, necessary modifications to the wording, sequence, and content of the tool were made before the

commencement of the actual data collection. Participants involved in the pretest were excluded from the main study.

5.8 Variables

5.8.1 outcome variables

- Prevalence of acute malnutrition

5.8.2 Explanatory variables

- Demographic: child's current age, sex and region
- Weight at surgery
- Age at surgery
- PDA diameter
- Pulmonary hypertension
- Preoperative comorbidities
    - Anemia (Hemoglobin < 11mg/dl)
    - others (generalized onset epilepsy, congenital sensorineural hearing loss, rickets, congenital cataract, autism spectrum disorder, intellectual disability with global developmental delay, and cleft lip and/or palate)
- Preoperative complications
    - Heart failure
- Types of interventions
    - Surgical ligation
    - Device closure
- Outcomes

5.9 Operational definition

- **Patent Ductus Arteriosus (PDA):** is a prevalent congenital heart defect defined by persistence of the fetal ductus arteriosus after birth, creating an aberrant vascular connection between the aorta and the pulmonary artery.

- **Malnutrition**: Defined by WHI Z-scores:

    - Wasting (Acute): Weight-for-Height (WHZ) or BMI-for-Age < -2SD.

- Stunting (Chronic): Height-for-Age (HAZ) < -2SD
- Underweight: Weight-for-Age (WAZ) <-2SD
- Overweight: Weight-for-Height (WHZ) or BMI-for-Age >+2SD.
- Obesity: Weight-for-Height (WHZ) or BMI-for-Age >+3SD.

- **Predictive factors:** demographics (age, sex), clinical history (age at surgery), PDA severity and presence or absence of pulmonary hypertension.
- **Pulmonary hypertension:** pulmonary hypertension (PH) is defined echocardiographically by an estimated Pulmonary Artery Systolic Pressure (ePASP) > 36mmhg.
    - Classification of severity by echocardiography based on the calculated ePASP and TR, PH is classified as follows:
        - Severity estimated PASP (ePASP)
            - Mild PH 37-50mmHg
            - Moderate PH 51-60mmHg
            - Severe PH PH > 60mmHg
- **Short-term postoperative nutritional outcomes:** measured at a predefined postoperative follow-up visit, i.e., 3 months
- **Heart failure:** Heart failure in children is a clinical and pathophysiological syndrome that results from ventricular dysfunction, volume or pressure overload, or excessive demands for cardiac output. It is characterized by specific clinical symptoms and signs, including tachycardia, tachypnea, rales, hepatomegaly and cardiomegaly (1).
- **Anemia:** is defined as a hemoglobin concentration below a specified cut-off point for a given age and sex, indicating an insufficient oxygen carrying capacity of the blood (1).

- **Categorical nutritional recovery:** a binary (yes/no) or ordinal outcome measuring a child's improvement across recognized nutritional categories.
- **Criteria**
    - **Yes:** an improvement from severe acute malnutrition (SAM) to moderate acute malnutrition (MAM) or normal status, or from MAM to normal status, based on WHZ or BMI for age.
    - **No:** remaining in the same nutritional category or deteriorating to worse category.

5.10 Data processing and analysis

After data collection by Google form, was checked for completeness and exported to SPSS version 27 for analysis.

Descriptive statistics were used to summarize the demographic, clinical and nutritional characteristics of the study participants. Categorical variables were presented as frequencies and percentages. Continuous variables were assessed for normality using the Shapiro-Wilk test and were presented as mean (± standard deviation) for normally distributed data or median (interquartile range) for non-normally distributed data. The results were presented using tables and figures.

The prevalence of wasting, stunting and underweight was calculated as proportions with 95% confidence intervals based on the World Health Organization (WHO) anthropometric Z-scores. Bivariate analysis was initially conducted using Chi-square tests for categorical variables and independent samples t-tests for continuous variables to assess associations between independent variables and nutritional status. Variables with a p-value <0.25 in the bivariate analysis were included in a multivariable binary logistic regression model to identify independent predictors of acute malnutrition. The results were reported as Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI). A p-value < 0.05 was considered statistically significant. Paired sample t-tests were used to compare preoperative and postoperative anthropometric Z-scores (WAZ,HAZ and WHZ) within the same group of children.

All anthropometric measurements were converted into Z-scores (Weight-for-Age (WAZ), Height-for-Age (HAZ), and Weight-for-Height (WHZ)) using WHO Anthro plus software (or equivalent SPSS macros) based on the WHO child growth standards(18). These Z-sores were used to classify the nutritional status of children.

5.11 Ethical consideration

Ethical clearance was obtained from the Department of Research and Ethical Review Committee (DRERC) of pediatrics and child health department. Then an official letter of support and ethical clearance was submitted to the record room. Confidentiality was maintained at all levels of the study, besides only the medical registration number (MRN) of study participants were used without mentioning the name and the collected information was kept in a secure place.

5.12 Dissemination and utilization of results

The findings of this research were submitted to Addis Ababa University health science and medical college, department of pediatrics and child health and presented during the final defense for partial fulfilment of specialty. Subsequently, an attempt will be made to present the findings on different review meetings, seminars and workshops. Furthermore, the manuscript will be published on peer reviewed journals.

6 Results

6.1 Demographic characteristics of the study participants

A total of 87 children with Patent Ductus Arteriosus (PDA) were included in the study. Thr median age of participants was 5 years (IQR: 2-8years, and nearly half 39 (44.8%) were > 5years and more than two third 60 (60.9%) were female. More than one third of 31 (35.6%) children were from Addis Ababa region. The details of demographic data are presented in table 1.

Table 1. Sociodemographic characteristics of children with PDA at TASH (n = 87) 2026

Variables		Frequency	Percent
Child's Current Age	0–1 Year	2	2.3
	>1 –2 Years	21	24.1
	>2 –5 Years	25	28.7

	6-9 years	22	25.3
	10-18 years	17	19.5
	Total	**87**	**100.0**
Sex	Male	27	31.0
	Female	60	69.0
	Total	**87**	**100.0**
Region	Addis Ababa	31	35.6
	Oromia	27	31.0
	Amhara	22	25.3
	SNNPE	6	6.9
	Dire Dawa	1	1.1
	Total	**87**	**100.0**

6.2 Clinical characteristics and PDA-related factors

Regarding clinical findings of the patients, the median PDA diameter was 5mm (IQR: 4-6mm). the children underwent surgery at varying ages: 11 (12.6%) were 0-1 year, 21 (24.1%) were > 1-2 years, 31 (35.6%) were > 2-5 years, and 24 (27.6%) were older than 5years. Pulmonary hypertension was present in 21 (24.1%) of children, with 4 (4.6%) classified as moderate and 17 (19.5%) as severe, while the remaining 66 (75.9%) had no pulmonary hypertension. Pre-operative comorbidities were common, with anemia (HB<11g/dl) being the most frequent one 29 (25.7%), followed by other comorbidities (including generalized onset epilepsy, congenital sensorineural hearing loss, rickets, congenital cataract, autism spectrum disorder, intellectual disability with global developmental delay and cleft lip and/or palate) were 11 (9.7%). Only 20 (17.7%) of children had no comorbidities. About 53 (46.9%) of children have heart failure as preoperative complication. The most 82 (94.3%) of children underwent surgical ligation, while 5 (5.7%) received device closure.

Table 2. Clinical and PDA characteristics of study participants at TASH 2026

		Frequency	Percent
Age at surgery	0–1 Year	11	12.6
	>1y–2 Years	21	24.1
	>2 –5 Years	31	35.6
	>5-9	13	14.9
	>9-18	11	12.6
	Total	87	100.0
Median (IQR) PDA diameter (mm)	5(4,6)		
Pulmonary Hypertension	None	66	75.9
	Moderate	4	4.6
	Severe	17	19.5
	Total	87	100.0
Pre-operative Comorbidities	None	20	33.3%
	Anemia (Hb<11~g/dL)	29	48.3%
	Other	11	18.3%
	Total	60	100.0%
Pre-operative complications (Heart failure)	No	34	39.1
	Yes	53	60.9
	Total	87	100.0

Type of Intervention	Surgical Ligation	82	94.3
	Device Closure	5	5.7
	Total	87	100.0

6.3 Prevalence of malnutrition

6.3.1 Distribution of pre- and post-operative anthropometric Z-scores

In our study normality of the study variables was evaluated using the Shaprio-Wilk test. Weight-for-age (pre-operative) showed no significant deviation from a normal distribution (P=0.409). similarly, body mass index (BMI) was approximately normally distributed (p=0.489). in contrast, weight-for-height Z-dcore (WHZ) demonstrated statistically significant deviation normality (p=0.015).

The mean preoperative height-for-age Z-score (HAZ) was −0.77 ± 1.97 (n = 87). The mean preoperative weight-for-age Z-score (WAZ) was −2.03 ± 1.41 (n = 78), and the mean preoperative BMI-for-age Z-score (BAZ) was −2.65 ± 1.30 (n = 33). The median preoperative weight-for-height Z-score (WHZ) was −2.73, with an interquartile range (IQR) of −3.62 to −1.29 (n = 54).

The normality of post-operative anthropometric indices. Height-for-age Z-score (HAZ) post-operation was normally distributed (W = 0.984, p = 0.362). Similarly, BMI post-operation followed a normal distribution (W = 0.968, p = 0.369). In contrast, weight-for-age Z-score (WAZ) post-operation showed a significant deviation from normality (W = 0.956, p = 0.011). Weight-for-height Z-score (WHZ) post-operation was also not normally distributed (W = 0.931, p = 0.005).

The mean postoperative height-for-age Z-score (HAZ) was −0.64 ± 2.07 (n = 87). The mean postoperative BMI-for-age Z-score (BAZ) was −1.74 ± 1.27 (n = 37). The median postoperative weight-for-age Z-score (WAZ) was −1.21, with an interquartile range (IQR) of −2.15 to −0.23 (n = 75). The median postoperative weight-for-height Z-score (WHZ) was −1.70 (IQR: −2.56 to 0.13, n = 52)

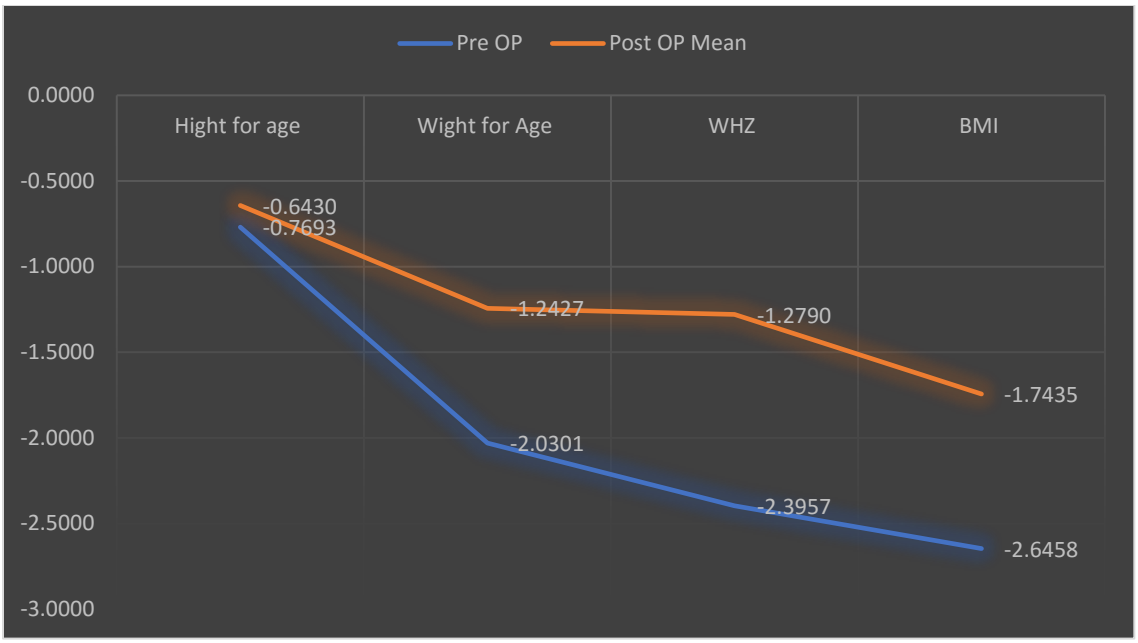
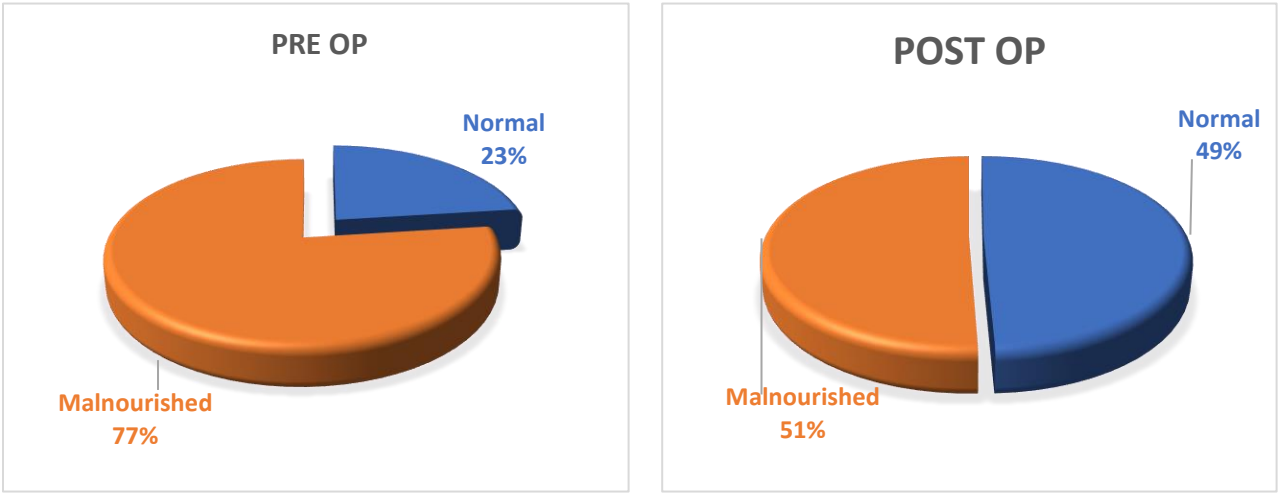


Figure 2. Means of Z-scores: pre-operation (0 mo.) and post operation (3 mos.) TASH, Addis Ababa, Ethiopia 2026

6.3.2 prevalence of preoperative malnutrition

The preoperative nutritional assessment showed that 20 patients (23.0%) had normal nutritional status, whereas the majority, 67 patients (77.0%), were malnourished.

Figure 3. prevalence of pre and post OP malnutrition at TASH, Addis Ababa, Ethiopia 2026



In this study, concerning the prevalence of acute malnutrition, 52 patients **(59.8%; 95% CI: 48.7–70.1)** were identified as malnourished, while 35 patients (40.2%; 95% CI: 29.9–51.3) had normal nutritional status.

Assessment of stunting indicated that 56 patients (64.4%) had normal height-for-age. However, 14 patients (16.1%) were stunted, and 11 patients (12.6%) were severely stunted. Additionally, 6 patients (6.9%) were classified as tall. Overall, 35.6% of the participants exhibited some degree of stunting.

Underweight status was assessed in 78 patients. Of these, 38 patients (48.7%) had normal weight-for-age, while 20 patients (25.6%) were underweighting and another 20 patients (25.6%) were severely underweight. This indicates that more than half of the assessed patients (51.2%) were underweight or severely underweight.

Wasting status was evaluated among 54 patients. Only 18 patients (33.3%) had normal weight-for-height. In contrast, 13 patients (24.1%) had moderate acute malnutrition, and 23 patients (42.6%) had severe acute malnutrition.

Body mass index (BMI) was assessed in 33 patients. Nearly half of 16 patients (48.5%), had normal BMI, while 7 patients (21.2%) were classified as thin and 10 patients (30.3%) as severely thin. Overall, 17(51.5%) of the participants had thinness or severe thinness.

6.3.3 Prevalence of postoperative malnutrition

The post-operative nutritional status assessment show that, nearly half of the participants were classified as nutritionally normal (43, 49.4%), while a slightly higher proportion were malnourished (44, 50.6%).

Regarding acute malnutrition, 58 (66.7%) children had normal nutritional status, whereas 29 (33.3%) were malnourished post-operatively.

Assessment of linear growth showed that 59 (67.8%) children had normal height-for-age. However, 11 (12.6%) were stunted and an equal proportion, 11 (12.6%), were severely stunted. A smaller proportion of children, 6 (6.9%), were classified as tall for age.

Underweight status was evaluated in 76 children. Of these, 56 (73.7%) had normal weight-for-age, while 9 (11.8%) were underweight and 11 (14.5%) were severely underweight.

Wasting was assessed among 53 children. Normal weight-for-height was observed in 30 (56.6%) participants. Moderate acute malnutrition was identified in 15 (28.3%), and severe acute malnutrition in 6 (11.3%) children. Overweight status was observed in 2 (3.8%) participants.

Body mass index (BMI) was calculated for 34 children. The majority, 27 (79.4%), had a normal BMI. Thinness was observed in 4 (11.8%) children, while 3 (8.8%) were classified as severely thin.

Table 3. Nutritional status of children with PDA at TASH (n = 87) 2026

Nutritional Indicator	Category	Pre-OP n (%)	Post-OP n (%)
Overall Nutritional Status	Normal	20 (23.0)	43 (49.4)
	Malnourished	67 (77.0)	44 (50.6)
Acute Malnutrition	Normal	35 (40.2)	58 (66.7)
	Malnourished	52 (59.8)	29 (33.3)
Stunting	Normal	56 (64.4)	59 (67.8)
	Stunted	14 (16.1)	11 (12.6)
	Severely Stunted	11 (12.6)	11 (12.6)
	Tall	6 (6.9)	6 (6.9)
Underweight	Normal	38 (48.7)	56 (73.7)
	Underweight	20 (25.6)	9 (11.8)
	Severely Underweight	20 (25.6)	11 (14.5)
Wasting	Normal	18 (33.3)	30 (56.6)
	Moderate Acute Malnutrition	13 (24.1)	15 (28.3)
	Severe Acute Malnutrition	23 (42.6)	6 (11.3)
	Overweight	–	2 (3.8)
BMI	Normal	16 (48.5)	27 (79.4)
	Thinness	7 (21.2)	4 (11.8)

	Severe Thinness	10 (30.3)	3 (8.8)

6.4 Postoperative nutritional outcomes

6.4.1 Changes in anthropometric Z-scores postoperatively

Paired samples t-tests were performed to assess changes in nutritional status before and after surgery. Significant improvements were observed in weight-for-age (WAZ), BMI-for-age (BMI-Z), and weight-for-height Z-scores (WHZ). Although height-for-age (HAZ) showed a slight improvement, the change was not statistically significant

The mean height-for-age Z-score increased slightly from −0.77 ± 1.97 preoperatively to −0.64 ± 2.07 postoperatively; however, this change was not statistically significant ($t(86) = -1.35$, $p = 0.179$). In contrast, weight-for-age Z-scores improved significantly following surgery, increasing from −2.01 ± 1.43 to −1.24 ± 1.29 ($t(74) = -8.47$, $p < 0.001$).

A significant improvement was also observed in weight-for-height Z-scores, which increased from −2.45 ± 1.59 preoperatively to −1.28 ± 1.61 postoperatively ($t(51) = -6.86$, $p < 0.001$). Similarly, BMI-for-age Z-scores showed a significant postoperative increase from −2.65 ± 1.30 to −1.77 ± 1.23 ($t(32) = -4.49$, $p < 0.001$).

Table 4. Paired Samples Comparison of Nutritional Indicators Before and After Surgery

Nutritional Indicator	N	Pre-OP Mean ± SD	Post-OP Mean ± SD	Mean Difference	t (df)	p-value
Height-for-Age (HAZ)	87	−0.77 ± 1.97	−0.64 ± 2.07	−0.13	−1.35 (86)	0.179
Weight-for-Age (WAZ)	75	−2.01 ± 1.43	−1.24 ± 1.29	−0.77	−8.47 (74)	<0.001*
Weight-for-Height (WHZ)	52	−2.45 ± 1.59	−1.28 ± 1.61	−1.17	−6.86 (51)	<0.001*
BMI-for-Age (BMI-Z)	33	−2.65 ± 1.30	−1.77 ± 1.23	−0.88	−4.49 (32)	<0.001*

6.4.2 Change in malnutrition prevalence postoperatively

The nutritional status of study participants was assessed before and the postoperative follow-up period (3 months), and changes were analyzed using McNemar's test for paired proportions.

With respect to general nutritional status (n = 87), there was a statistically significant improvement in the postoperative period. The proportion of patients with normal nutritional status increased from 20 (23.0%) preoperatively to 43 (49.4%) postoperatively, while the prevalence of malnutrition decreased from 67 (77.0%) to 44 (50.6%) ($p < 0.0006$).

A significant reduction in acute malnutrition was also observed. Preoperatively, 35 patients (40.2%) were nutritionally normal and 52 (59.8%) were malnourished. Postoperatively, the proportion of nutritionally normal patients increased to 58 (66.7%), whereas malnutrition decreased to 29 (33.3%). This change was statistically significant ($p < 0.00003$).

In contrast, stunting (HAZ) did not show a statistically significant change following surgery. The proportion of patients with normal height-for-age increased slightly from 62 (71.3%) to 65 (74.7%), while the prevalence of stunting decreased from 25 (28.7%) to 22 (25.3%). However, this difference was not statistically significant ($p = 0.63$).

Assessment of underweight status (WAZ) revealed a significant postoperative improvement. The proportion of patients with normal weight-for-age increased from 38 (48.7%) in the preoperative period to 56 (73.7%) postoperatively, while underweight prevalence declined from 40 (51.3%) to 20 (26.3%) ($p < 0.0004$).

Similarly, wasting (WHZ) showed a statistically significant reduction after surgery. Normal weight-for-height increased from 18 (33.3%) preoperatively to 32 (60.4%) postoperatively, while wasting decreased from 36 (66.7%) to 21 (39.6%) ($p = 0.002$).

With regard to BMI-for-age (BAZ), a significant improvement was observed postoperatively. The proportion of participants with normal BMI increased from 16 (48.5%) to 27 (79.4%), while thinness declined from 17 (51.5%) to 7 (20.6%) ($p = 0.014$).

Table 5. Prevalence of Preoperative and Postoperative Nutritional Status Among Children with PDA

Nutritional Indicator	Category	Pre-OP n (%)	Post-OP n (%)	p-value
General Nutritional Status (n=87)	Normal	20 (23.0)	43 (49.4)	<0.0006*
	Malnourished	67 (77.0)	44 (50.6)	
Acute Malnutrition (n=87)	Normal	35 (40.2)	58 (66.7)	<0.00003*
	Malnourished	52 (59.8)	29 (33.3)	
Stunting (HAZ < -2) (n=87)	Normal (≥ -2)	62 (71.3)	65 (74.7)	0.63
	Stunted (< -2)	25 (28.7)	22 (25.3)	
Underweight (WAZ < -2)	Normal (≥ -2)	38 (48.7) ^a	56 (73.7) ^b	<0.0004*
	Underweight (< -2)	40 (51.3)	20 (26.3)	
Wasting (WHZ < -2)	Normal (≥ -2)	18 (33.3) ^c	32 (60.4) ^d	0.002*
	Wasted (< -2)	36 (66.7)	21 (39.6)	
BMI-for-Age (BAZ < -2)	Normal (≥ -2)	16 (48.5) ^e	27 (79.4) ^f	0.014*
	Thinness (< -2)	17 (51.5)	7 (20.6)	

*McNemar's test for paired proportions; ^a n=78, ^b n=76, ^c n=54, ^d n=53, ^e n=33, ^f n=34

6.5 Predictive factors for preoperative malnutrition

Bivariable and multivariable logistic regression analyses were performed to identify factors associated with acute malnutrition among the study participants. Variables included in the model were sex, pulmonary hypertension, anemia, heart failure, other comorbidities, type of intervention, and age at surgery.

In the multivariable analysis, sex remained a statistically significant predictor of acute malnutrition. Female children had 67% lower odds of being acutely malnourished compared to males (AOR = 0.33; 95% CI: 0.15–0.98; p = 0.04).

Other comorbidities, including generalized onset epilepsy, congenital sensorineural hearing loss, rickets, congenital cataract, autism spectrum disorder, intellectual disability with global developmental delay, and cleft lip and/or palate, were independently associated with acute malnutrition. Children with at least one of these conditions had significantly higher odds of being acutely malnourished compared with those without other comorbidities (AOR = 10.2; 95% CI: 1.21–97.85; p = 0.03).

Although higher odds of acute malnutrition were observed among children with moderate and severe pulmonary hypertension, anemia, heart failure, and those who underwent device closure, these associations did not reach statistical significance after adjustment for potential confounders (p > 0.05 for all). Age at surgery was also not significantly associated with acute malnutrition in either bivariable or multivariable analysis.

Table 6. Factors Associated with Preoperative Malnutrition: Multivariable Logistic Regression Analysis

		Normal n (%)	**Malnourished n (%)**	**Bivariable analysis**	**Multivariable analysis**	**P value**
Sex	Male	7 (25.9)	20 (74.1)	1	1	**0.04***
	Female	28 (46.7)	32 (53.3)	0.4[0.14-1.08]	0.33[0.15-0.98]	
Pulmonary Hypertension	None	28 (42.4)	38 (57.6)	1	1	0.48
	Moderate	1 (25.0)	3 (75.0)	2.2[0.21-22.38]	1.16[0.76-1.76]	
	Severe	6 (35.3)	11 (64.7)	1.35[0.44-4.09]	1.53[0.42-5.54]	
Anemia (Hb < 11 g/dL)	No	25 (43.1)	33 (56.9)	1	1	0.3
	Yes	10 (34.5)	19 (65.5)	1.43[0.57-3.63]	1.76[0.60-5.18]	
Heart Failure	No	13 (39.4)	20 (60.6)	1	1	0.95
	Yes	22 (41.5)	31 (58.5)	0.91[0.37 -2.22]	0.97[0.35-2.66]	
Other Comorbidities	No	34 (44.7)	42 (55.3)	1	1	**0.03***
	Yes	1 (9.1)	10 (90.9)	8[0.98-66]	10.2[1.21-97.85]	
Type of Intervention	Surgical ligation	34 (41.5)	48 (58.5)	1	1	0.11

	Device closure	1 (20.0)	4 (80.0)	2.8[0.3-26.4]	0.15[0.015-1.54]	
Age at surgery				0.64[0.40-1.01]	0.96[0.82-1.12]	0.65

*Model adjusted for all variables listed; Hosmer-Lem show goodness-of-fit test: χ^2=12.2, p=0.138; Nagelkerke R^2=0.19

7. Discussion

This study aimed to assess the prevalence and predictive factors of malnutrition and its short-term postoperative outcomes among children with Patent Ductus Arteriosus (PDA) at Tikur Anbessa Specialized Hospital (TASH). The findings reveal a starkly high burden of preoperative malnutrition, a significant improvement in most nutritional parameters within 3 months of surgical correction, and the identification of key demographic and clinical factors that predispose children to this comorbidity. This discussion will interpret these findings in the context of existing literature, explore their implications, acknowledge the study's limitations, and propose directions for future result.

7.1 High burden of preoperative malnutrition

The first major finding of this study is the alarmingly high prevalence of preoperative malnutrition among children included in this study. Over three-quarters (77.0%) of the children were malnourished, with 59.8% specifically classified as acutely malnourished. The severity is particularly striking: more than half (51.2%) were underweight or severely underweight, and two-thirds (66.7%) of those assessed for wasting presented with moderate or severe acute malnutrition. These figures are consistent with the dire situation reported in other Ethiopian studies, such as the 60.5% underweight prevalence among infants with CHD cited by Woldesenbet et al.(3) and the study done in university of Gonder specialized hospital, northwest Ethiopia by Asrade et al. showed high rates of acute malnutrition (65.7%) among children with congenital heart disease (2). Furthermore, our findings echo the global picture of malnutrition in CHD , as documented in Tertiary teaching hospital in Lagos, Nigeria where it found around 90.4% of CHD patients had preoperative malnutrition and systematic review and meta-analysis which included 39 studies the pooled estimates of preoperative malnutrition in children with

CHD were 27.4% (95% CI,21.7-34.0) for underweight, 24.4% (95% CI, 19.5-30.0) for stunting, and 24.8% (95% CI, 19.3-31.3) for wasting(4,16), confirming that children with PDA in our study face a nutrition crisis that is as severe as, or worse than, their peers in other settings. This high prevalence is likely a consequence of the pathophysiological burden of PDA itself namely pulmonary over circulation, increased work of breathing, and heart failure, which dramatically increases metabolic demands and energy expenditure(1,6), while simultaneously making feeding difficult and inefficient(19).

7.2 Significant postoperative nutritional recovery

A crucial and highly encouraging finding of this study is significant improvement in nutritional status just three months after surgical correction. We observed statistically significant improvements in mean weight-for-age (WAZ), weight-for-height (WHZ), and BMI-for-age (MAZ) Z-scores. This translated into a remarkable reduction in the overall prevalence of malnutrition from 77.0% to 50.6%, and an even more dramatic drop in acute malnutrition from 59.8% to 33.3%. The proportion of children with wasting was decreased by nearly half (from 66.7% to 39.6%). This rapid nutritional recovery aligns with the psychological rationale for intervention: once the left-to-right shunt is eliminated, the pulmonary over circulation resolves, cardiac function improves and the body's energy can be redirected from the work of cardiorespiratory compensation to growth and development (7). Our results are consistent with international studies that have demonstrated significant catch-up growth in the months following cardiac surgery (8,13,16). The study by Vaidyanathan et al. (13) similarly highlighted that while weight recovery is often swift, linear growth catch-up is a slower process. This is mirrored in our finding that, despite significant improvements in weight-based metrics, the change in stunting (HAZ) was not statistically significant, suggesting that linear growth recovery requires a longer postoperative period.

7.3 Predictive factors for preoperative malnutrition

Identifying the factors that place a child at the highest risk of malnutrition is essential for targeted intervention. Our multivariable analysis revealed two independent predictors.

First, sex emerged as a significant factor, with female children having 67% lower odds of being acutely malnourished compared to males. This finding is intriguing and contrasts with some

studies that have found no sex-based difference (2,11) or even the opposite (4). It is possible that this reflects the number of male patients involved in this study were small which might have exaggerated this finding. This novel finding warrants further investigation, as it suggests that male children with PDA in our setting may constitute a particularly vulnerable subgroup requiring heightened nutritional screening and support.

Second, the presence of other comorbidities (a group including neurological, genetic and musculoskeletal conditions such as epilepsy, developmental delay, and cleft lip/palate) was a powerful predictor, increasing the odds of acute malnutrition by more than tenfold (AOR=10.2). This finding is both intuitive and clinically critical. These comorbidities independently contribute to feeding difficulties (e.g., orofacial clefts, developmental delay), increased metabolic demand (e.g., epilepsy) and global growth impairment (5,6). When these conditions are superimposed on the hemodynamic burden of a PDA, the cumulative risk for severe malnutrition becomes extremely high. Our finding encourages the strengthened multidisciplinary approach to enhance the care given to these children and involving dieticians and genetists to improve their nutritional status even better.

While pulmonary hypertension, anemia and heart failure showed trends towards higher odds of malnutrition in the bivariate analysis, they did not retain statistical significance in the multivariable model. This may be due to the relatively small sample size within these subgroups. This is in line with a study done at University of Gonder specialized referral hospital, northwest Ethiopia that reported children with advanced congestive heart failure and/or pulmonary hypertension were more likely to be malnourished (2). Another study done in Thia found that among CHD patients who had congestive heart failure were four times at risk of being malnourished than those without clinical manifestations of congestive heart failure (16). This association may be explained by congestion of bowel and liver leading to early satiety. In addition, heart failure activates the sympathetic nervous system, leading to decreased appetite and increased caloric demand (20).

On this study, Age at surgery was not a significant predictor, which may be due to the smaller number of sample size included in this study and due to the tendency of selecting sicker children for earlier intervention which exaggerates the worse postoperative outcomes of these children.

8. Limitations of the study

The findings of this study should be interpreted in light of its limitations. First, the sample size of 87, while adequate for the primary objectives, may have limited the statistical power to detect significant associations for some variables in the multivariable regression analysis (e.g., pulmonary hypertension). Second, the follow up period of three months, while sufficient to demonstrate significant weight gain, is too short to fully assess long-term outcomes, particularly the catch-up in linear growth (stunting). Third, data was collected from chart review which did not allow us to collect detailed data on socioeconomic status, household food security, or specific dietary intake and feeding practices, which are known to be important determinants of malnutrition (2,4,21). Their absence may mean that our model does not fully capture all relevant predictors. In addition, we found erratic anthropometric measurements of weight and height which also impacted this study. Finally, the single-center design at TASH, a tertiary referral hospital, may limit the generalizability of our findings to children with PDA managed at other hospitals.

9. Recommendation for future research

Based on these findings and limitations, future research should focus on:

(1) Conducting multi-center studies with larger cohorts to validate the predictive factors identified here and to explore the intriguing sex-based difference.
(2) Extending the follow-up period to the least one year to assess the trajectory of linear growth recovery and the durability of weight gain.
(3) Incorporating detailed assessments of household food security, maternal education, and dietary diversity (19) to provide a more holistic understanding of the drivers of malnutrition; and
(4) Use standard age-based reference ranges for some parameters like anemia.
(5) Evaluating the effectiveness of specific, targeted nutritional interventions in the preoperative period for high-risk groups identified in this study.

10.Conclusions

In conclusion, this study reveals a high prevalence of preoperative malnutrition among children with Patent Ductus Arteriosus included in this study. The findings further demonstrate that the presence of additional comorbidities is a major contributor to poorer postoperative outcomes. Most importantly, this research provides compelling evidence that surgical correction of PDA leads to a significant improvement in the nutritional status of these children, as assessed three months postoperatively. These results highlight the critical need for targeted nutritional interventions and comprehensive management of comorbidities to optimize surgical outcomes and support healthy growth in this vulnerable population.

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12.Annexes

Annexes I

Data Collection Tool (Questionnaire)

Study Questionnaire: Prevalence and Predictive Factors of Malnutrition in Children with PDA and Short-Term Postoperative Nutritional Outcomes

Study ID: _____
Date of Data Collection: ___/___/____ (DD/MM/YYYY)
Data Collector's Name: _____

Part 1: Demographic Characteristics (Predictive Factors)

(Data from Medical Chart Review)

No.	Question	Answers
1.1	Child's Age	[ ]years [ ]months
1.2	Child's Sex	[ ] Male [ ] Female
1.3	Region	_____

Part 2: Clinical History & PDA Characteristics (Predictive Factors)

(Data from Medical Chart Review)

No.	Question	Answers / Instructions
3.1	Age at surgery (in kilograms)	_____ Kg
3.3	**PDA Severity (from most recent pre operative Echo)**	
	a) PDA Diameter (mm)	_____ mm

No.	Question	Answers / Instructions
	b) Hemodynamically Significant PDA? *(>1.5mm or LA:Ao >1.4)* c) pulomonary hypertension	[ ] Yes [ ] No [ ]none [ ]mild [ ]moderate [ ]severe
3.4	Pre-operative Comorbidities	[ ] None [ ] Anemia (Hb < 11 g/dL) [ ] Heart Failure [ ] Other: _____
3.6	Type of Intervention	[ ] Surgical Ligation [ ] Device Closure

Part 4: Anthropometric Measurements for Nutritional Status & Postoperative Outcomes

A. Pre-Operative Measurement *(Date: ___/___/____)*

Measurement	Value
Weight (kg)	_____ kg
Length/Height (cm)	_____ cm
Standardization *WAZ* ---------- *HAZ*---------- *WHZ* ---------- *BMI for age*--------- *(for age > 5years old)*	

B. Short-Term Postoperative Measurement *(Date: ___/___/____; At 3rd month follow-up)

Measurement	Value
Weight (kg)	_____ kg
Length/Height (cm)	_____ cm
Standardization *WAZ----------* *HAZ----------* *WHZ----------* *BMI for age----------* *(for age > 5years old)*	
Categorical Nutritional Recovery	[ ] Improved [ ] No change [ ] Deteriorated *(Based on WHO categories)*