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CONGENITAL HEART DISEASE OUTCOMES AND POSTOPERATIVE COMPLICATIONS: A REGIONAL STUDY FROM BUKHARA, UZBEKISTAN

Nodirabegim Kasimova, Assistant, Department of Pediatrics №2, Bukhara State Medical Institute, Bukhara, Uzbekistan

Abstract

This study analyzed the clinical and epidemiological characteristics of children following surgical correction of congenital heart defects in the Bukhara region of Uzbekistan. A retrospective analysis of 145 pediatric patients was conducted, assessing demographic characteristics, nutritional status, comorbidities, and postoperative complications. A high prevalence of malnutrition and cardiac arrhythmias was identified in the late postoperative period. A strong correlation was observed between patient age and the incidence of arrhythmias. These findings highlight the need for a multidisciplinary rehabilitation approach with emphasis on nutritional support and long-term cardiac monitoring.

Keywords: Congenital heart disease, postoperative complications, malnutrition, arrhythmias, Uzbekistan, global health.

ИСХОДЫ ВРОЖДЕННЫХ ПОРОКОВ СЕРДЦА И ПОСЛЕОПЕРАЦИОННЫЕ ОСЛОЖНЕНИЯ: РЕГИОНАЛЬНОЕ ИССЛЕДОВАНИЕ В БУХАРСКОЙ ОБЛАСТИ, УЗБЕКИСТАН

Нодирабегим Касымова, ассистент кафедры педиатрии № 2,
Бухарский государственный медицинский институт, Бухара, Узбекистан

Аннотация

В исследовании проанализированы клинико-эпидемиологические особенности детей после хирургической коррекции врожденных пороков сердца в Бухарской области Узбекистана. Ретроспективно изучены данные 145 пациентов с оценкой демографических характеристик, нутритивного статуса, сопутствующей патологии и послеоперационных осложнений. Установлена высокая распространённость дефицита питания и нарушений сердечного ритма в отдалённом послеоперационном периоде. Выявлена выраженная корреляция между возрастом пациентов и частотой развития аритмий. Полученные результаты подчеркивают необходимость мультидисциплинарного подхода к реабилитации с акцентом на нутритивную поддержку и длительный кардиологический мониторинг.

Ключевые слова:
врожденные пороки сердца, послеоперационные осложнения, нутритивная недостаточность, аритмии, Узбекистан, глобальное здравоохранение.

List of Abbreviations

CHD	Congenital Heart Disease
VSD	Ventricular Septal Defect
ASD	Atrial Septal Defect
ToF	Tetralogy of Fallot
PDA	Patent Ductus Arteriosus
BMI	Body Mass Index
CHF	Chronic Heart Failure
LMICs	Low- and Middle-Income Countries
WHO	World Health Organization

Introduction

Congenital heart disease (CHD) remains a leading cause of infant morbidity and mortality worldwide, representing a significant challenge for global health systems[1]. While advancements in surgical techniques have dramatically improved early survival rates, the focus of pediatric cardiac care is shifting toward long-term outcomes and the quality of life of survivors[2, 3]. As highlighted in recent advocacy analyses, the success of a surgical program in low- and middle-income countries (LMICs) is measured not only by operative mortality but by the effectiveness of longitudinal follow-up and the implementation of robust public health frameworks[1, 4].

In many LMICs, including the regions of Central Asia, geographical and socioeconomic factors significantly impact the post-surgical trajectory of pediatric patients[5, 6]. Challenges such as limited access to specialized cardiology centers in rural areas, severe nutritional deficiencies, and sociocultural factors can complicate the recovery process [7, 8]. Malnutrition, in particular, has been identified as a critical predictor of adverse outcomes in children with CHD, necessitating a paradigm shift toward multidisciplinary perioperative management and targeted nutritional support [7,9,10].

In Uzbekistan, the centralization of cardiac surgery has expanded access to life-saving procedures; however, the regional management and dispensary observation of these patients post-discharge remains a field requiring urgent optimization[11]. The Bukhara region, characterized by a high proportion of rural residents and specific environmental conditions, presents a unique demographic for studying CHD outcomes[12]. Understanding the prevalence of late-onset complications, such as cardiac rhythm and conduction disturbances, and their correlation with age and nutritional status is essential for developing regional rehabilitation protocols[13,14]. These arrhythmias, often emerging long after the initial repair, remain a primary driver for late morbidity and potential reoperation[15, 16].
This study aims to evaluate the clinical and epidemiological profile of children in the Bukhara region following surgical correction of CHD. By analyzing the intersection of nutritional status, late-onset arrhythmias, and environmental resources, we seek to identify strategies to

enhance the quality of medical rehabilitation and long-term surveillance in this specific population.

Methods

This retrospective observational study was conducted at the Bukhara Regional Children's Multidisciplinary Medical Center. The study period encompassed a comprehensive analysis of pediatric patients who had previously undergone surgical correction for various forms of congenital heart disease (CHD). The primary objective was to evaluate their clinical status, growth parameters, and the incidence of late postoperative complications in a regional setting.

A total of 145 pediatric patients (aged 0 to 18 years) were included in the study. Inclusion criteria were: (1) confirmed diagnosis of CHD; (2) history of surgical repair or palliation; (3) residency within the Bukhara region for at least one year post-surgery. Patients with incomplete medical records or those lost to follow-up were excluded from the analysis.

Data were systematically collected from inpatient medical histories, outpatient records, and structured interviews with parents during follow-up visits. The following parameters were analyzed:

- Demographics**:** Age, gender, and geographic location (rural vs. urban).
- Clinical Profile**:** Type of CHD (classified into cyanotic and acyanotic groups), presence of consanguineous marriage, and history of somatic comorbidities.
- Nutritional Assessment: Anthropometric measurements were taken to calculate the Body Mass Index (BMI). Nutritional status was classified according to WHO growth charts[17].
- Postoperative Outcomes: Incidence of cardiac arrhythmias, chronic heart failure (CHF), and adherence to the national vaccination schedule.

Ethical integrity was maintained throughout the study, which received formal approval from the Institutional Ethics Committee of the Bukhara State Medical Institute (Protocol No: 9, from March 30, 2025). In strict adherence to the Declaration of Helsinki and the current healthcare legislation of the Republic of Uzbekistan[18, 19], written informed consent was secured from the parents or legal guardians of all 145 pediatric participants before their data was analyzed

Statistical processing was performed using SPSS Statistics (Version 26.0). Descriptive statistics were used to summarize demographic and clinical data. Quantitative variables were expressed as mean ± standard deviation (SD). For categorical data, frequencies and percentages were calculated. To assess the relationship between age and postoperative complications (arrhythmias), Spearman's rank correlation coefficient (ρ) was utilized. P-values less than 0.05 were considered statistically significant[2].

Results

The study cohort consisted of 145 patients (Table 1), with a slight male predominance (n=78, 53.8%). A striking majority of the patients (n=121, 83.4%) were residents of rural areas. Geographic analysis revealed that the highest number of patients originated from the Gijduvan (n=34, 23.4%) and Jondor (n=19, 13.1%) districts. Notably, consanguineous marriages were reported in 7.6% of families (n=11), highlighting a specific sociocultural risk

factor within the region that aligns with broader patterns discussed by Bokeria et al. and Hamamy[5,20].

Table 1. Demographic and Socio-Economic Profile of the Study Cohort (N=145)

Characteristic	n (%) or Mean ± SD
Gender	
Male	78 (53.8%)
Female	67 (46.2%)
Age at Follow-up (years)	7.4 ± 3.2
Residential Area	
Rural	121 (83.4%)
Urban	24 (16.6%)
Key Geographic Districts	
Gijduvan	34 (23.4%)
Jondor	19 (13.1%)
Bukhara City	17 (11.7%)
Others (10 districts)	75 (51.8%)
Social Risk Factors	
Consanguinity (Related parents)	11 (7.6%)
Suboptimal Vaccination Adherence	37 (25.5%)

The distribution of CHD types (Table 2) followed global trends for regional centers. The most frequent pathology was Ventricular Septal Defect (VSD), accounting for 21.4% (n=31) of cases, followed by Atrial Septal Defect (ASD) at 15.9% (n=23). Among cyanotic defects, Tetralogy of Fallot (ToF) was the most prevalent, representing 13.8% (n=20) of the cohort. This distribution is consistent with reports from other developing cardiac programs[1,6] and aligns with regional epidemiological data for the Bukhara region provided by Navruzova et al. (2015), who also identified VSD as the leading acyanotic defect in the local pediatric population[21]. Other diagnoses included Patent Ductus Arteriosus (PDA) (11.0%) and complex combined defects (10.3%).

Table 2. Clinical Spectrum of Congenital Heart Defects (CHD)

Type of CHD	Absolute Number (n)	Percentage (%)
Ventricular Septal Defect (VSD)	31	21.4%
Atrial Septal Defect (ASD)	23	15.9%
Tetralogy of Fallot (ToF)	20	13.8%
Patent Ductus Arteriosus (PDA)	16	11.0%
Combined/Complex Defects	15	10.3%
Other	40	27.6%
Total	145	100.0%

Nutritional deficiency was a pervasive finding (Table 3). According to BMI analysis, 61.4% of children (n=89) suffered from malnutrition (BMI < 18.5). Statistical analysis demonstrated a significant correlation between low BMI and a higher incidence of postoperative complications ($p = 0.0005$). Furthermore, 75.0% of patients presented with at least one somatic comorbidity, with iron-deficiency anemia being the most common (37.9%), followed by neurological disorders (11.0%) and chronic tonsillitis (8.3%).

Table 3. Nutritional Status and Somatic Comorbidities

Parameter	Category	n	%
Nutritional Status (BMI)	Malnutrition (BMI < 18.5)	89	61.4%
	Normal Weight	56	38.6%
Comorbidities	Iron-Deficiency Anemia	55	37.9%
	Neurological Disorders	16	11.0%

	Chronic Tonsillitis	12	8.3%
	Gastrointestinal Diseases	11	7.6%
	No Comorbidities	36	24.8%

At the time of follow-up, 42 patients (28.9%) exhibited significant late-stage cardiac complications (Table 4). The leading issues were cardiac arrhythmias (31.0%), chronic heart failure (26.2%), and pulmonary hypertension (16.7%).

Table 4. Late Postoperative Complications and Statistical Correlations

Complication Type	Number of Cases (n=42)	Percentage (%)
Cardiac Arrhythmias	13	31.0%
Chronic Heart Failure (CHF)	11	26.2%
Pulmonary Hypertension	7	16.7%
Statistical Analysis	Metric	Value
Age vs. Arrhythmia Risk	Spearman's p	0.98 ($p < 0.001$)
Low BMI vs. Complications	Chi-square / p-value	$p = 0.0005$

A Spearman correlation analysis revealed a near-perfect positive relationship between the patient's age at follow-up and the manifestation of arrhythmias ($\rho = 0.98$, $p < 0.001$). This suggesting that electrical instability increases significantly as the post-surgical population ages, consistent with observations by Ganea[22] and Sahu et al.[23].

Additionally, adherence to the national vaccination schedule was suboptimal, with 25.5% of children missing primary vaccinations due to medical contraindications or parental hesitancy.

Discussion

The results of this study highlight the complex interplay between clinical, nutritional, and regional factors influencing the long-term outcomes of pediatric patients after CHD correction in the Bukhara region.

One of the most concerning findings is the high prevalence of malnutrition (61.4% with BMI < 18.5). This rate is significantly higher than those reported in developed countries but aligns with data from other low- and middle-income countries (LMICs). For instance, Argent[24] and Skillman[25] emphasize that perioperative undernutrition is a major predictor of increased morbidity and prolonged recovery. Our finding of a strong statistical significance ($p = 0.0005$) between low BMI and postoperative complications underscores the urgent need for standardized nutritional support protocols in regional pediatric cardiac centers.

The near-perfect correlation between age and the incidence of arrhythmias ($\rho = 0.98$, $p < 0.001$) is a critical observation. This suggests that as the first cohorts of successfully operated children in the region reach adolescence, the burden of electrical instability and rhythm disorders increases exponentially. This phenomenon has been well-documented in long-term follow-ups of Tetralogy of Fallot patients[26, 27]. The high incidence of late-onset arrhythmias in our cohort (31.0%) suggests that regional follow-up programs must prioritize long-term electrophysiological monitoring, especially as patients transition into adulthood.

The fact that 83.4% of our patients reside in rural areas poses a significant challenge for specialized rehabilitation. Geographic barriers often lead to suboptimal adherence to follow-up schedules and vaccination protocols (25.5% deviation in our study). Furthermore, the 7.6% rate of consanguinity, while typical for some parts of Central Asia, is a known risk factor for complex CHD presentations and associated genetic comorbidities[20]. These findings suggest that a "one-size-fits-all" rehabilitation model is insufficient; instead, a community-based, multidisciplinary approach is required to bridge the gap between rural residences and specialized centers.

Our findings in the Bukhara region present both striking similarities and notable divergences when compared to global benchmarks (Table 5):

1. Late-Onset Arrhythmias: Our observed correlation between age and arrhythmia incidence ($\rho = 0.98$) mirrors the long-term data from the Mayo Clinic and Boston Children's Hospital, where late-onset rhythm disturbances in Tetralogy of Fallot survivors typically peak during the second decade of life. However, while global studies often attribute this to surgical scarring alone (Ganea et al., 2023)[22], our data suggests that in LMIC settings, chronic malnutrition may accelerate this electrical instability.

2. Nutritional Burden: The 61.4% malnutrition rate in our cohort is significantly higher than reported in European or North American registries, where pediatric cardiac cachexia is strictly managed through early aggressive enteral nutrition. Our results are more closely aligned with data from India[28] and Brazil[29], where preoperative undernutrition remains a primary predictor of prolonged mechanical ventilation and late morbidity.

3. Socio-Geographic Barriers: Unlike the centralized models in Russia reported by the Bakulev Center[5] where geographic availability is a logistical issue, our study highlights that in Bukhara, the high rural density (83.4%) combined with sociocultural factors like consanguinity (7.6%) creates a unique 'risk cluster' that is not typically seen in Western populations.

Table 5. Comparative analysis of postoperative outcomes: Bukhara vs. International cohorts

Parameter	Bukhara Cohort (Our Study)	International Trends (LMICs)	Developed Centers (USA/EU)
Malnutrition Rate	61.4%	35–50% (India/Africa)	< 10%
Late Arrhythmias	31.0% (of complications)	20–30%	15–25% (longer follow-up)
Rural Residency	83.4%	40–60%	< 20%
Main Correlation	Age & BMI (ρ = 0.98)	Surgical Technique	Genetic Predisposition

Study Limitations

This study is limited by its retrospective nature and the reliance on medical records which may have inherent documentation gaps. Additionally, the sample size of 145, while representative for the Bukhara region, may not capture rarer complications or late-term outcomes in less common CHD types.

Conclusion

Postoperative management of congenital heart disease in the Bukhara region is characterized by a high burden of nutritional deficiencies and age-related complications. The significant correlation between increasing age and the incidence of cardiac arrhythmias (ρ =0.98) highlights a critical need for long-term, specialized electrophysiological monitoring as this surgical cohort matures.

Furthermore, the high prevalence of malnutrition (61.4%) and its direct impact on postoperative morbidity (p=0.0005) necessitate the integration of aggressive nutritional rehabilitation into standard regional protocols. Given that over 80% of patients reside in rural areas, success in long-term outcomes will depend on creating a multidisciplinary bridge between regional specialized centers and primary rural healthcare providers.

Disclosures and Conflict of Interest The authors declare that this study was conducted without any financial, property, or intellectual aid from commercial sources. No funds, property, or technology used in this study were purchased, borrowed, or donated by commercial entities. The authors have no conflicts of interest to disclose.

Freedom of Investigation The authors affirm that they had full control over the study design, the methods used, the selection of outcome parameters, the analysis of data, and the production of the final written report. There are no undisclosed authors associated with this manuscript.

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