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Original article

Impaired Exercise Capacity and Mortality Risk in Adults with Congenital Heart Disease

Dr Rahul Banik, Dr Mohammad Abid Geelani, Dr Harpreet Singh

Department of Cardiothoracic and Vascular Surgery
Govind Ballabh Pant Institute of Postgraduate Medical Education and Research, New Delhi
Corresponding author : Dr Rahul Banik

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Abstract:

Background: The prevalence of congenital heart disease (CHD) among adults has increased due to improved medical care. Impaired exercise capacity is a significant concern in this population, with potential implications for mortality risk.

Methods: A retrospective cohort study involving 40 adults with CHD was conducted over one year. Exercise capacity parameters (peak VO2, exercise duration, peak heart rate) were assessed using cardiopulmonary exercise testing. Mortality outcomes were recorded, and Cox proportional hazards regression and Kaplan-Meier survival analyses were performed.

Results: Mean peak VO2 was 22.1 ± 3.8 ml/kg/min, exercise duration was 8.5 ± 2.1 min, and peak heart rate was 156 ± 12 bpm. During the study, 15% (n=6) of participants experienced mortality. Associations between exercise capacity parameters and mortality risk were observed, but did not reach statistical significance (peak VO2: HR = 0.81, p = 0.065; exercise duration: HR = 0.95, p = 0.487; peak heart rate: HR = 1.12, p = 0.188). Kaplan-Meier survival analysis showed a declining survival probability over 12 months (77%).

Conclusion: This study highlights potential trends between impaired exercise capacity and mortality risk in adults with CHD. While associations were not statistically significant, the findings underscore the need for further research with larger samples and longer follow-up periods to comprehensively understand the complex relationship between exercise capacity and mortality outcomes in this population.

Keywords: Congenital heart disease, exercise capacity, mortality risk.

Introduction:

The prevalence of adults living with congenital heart disease (CHD) has significantly increased due to advances in medical care, resulting in improved survival rates.(1) However, this population still faces substantial challenges, with impaired exercise capacity being a prominent concern. Exercise capacity serves as a critical marker of overall cardiovascular health and has profound implications for long-term outcomes, including mortality risk.(2,3)

Despite the advancements in congenital heart disease management, a substantial proportion of adults with CHD experience limitations in their ability to engage in physical activities. (4) Impaired exercise capacity can stem from a variety of factors, including residual cardiac anomalies, reduced cardiac output, impaired oxygen transport, and altered pulmonary function. This compromised ability to engage in physical exercise not only diminishes the individual's quality of life but also raises concerns about potential adverse outcomes.(5,6,7)

Understanding the intricate relationship between impaired exercise capacity and mortality risk in adults with congenital heart disease is a vital area of research that warrants comprehensive investigation. (8) By elucidating the complex interplay between physiological factors, cardiac function, and mortality outcomes, our research work aims to provide valuable insights into risk stratification, early intervention strategies, and optimized clinical management for this unique patient population. (9)

Material and methods:

A retrospective study was conducted to investigate the relationship between impaired exercise capacity and mortality risk in adults with congenital heart disease (CHD).

The study included a sample size of 40 patients, all of whom were diagnosed with various forms of CHD and were actively managed at a tertiary care center. The study spanned a duration of one year, during which data was collected from electronic medical records, exercise testing reports, and follow-up assessments.

Inclusion Criteria:

1. Adults aged 18 years or older.
2. Confirmed diagnosis of congenital heart disease (CHD) based on medical records and imaging studies.
3. Under active follow-up and management at the participating tertiary care center.
4. Ability to undergo cardiopulmonary exercise testing and provide valid exercise performance data.

Exclusion Criteria:

1. Severe comorbidities (e.g., advanced renal or hepatic dysfunction, active malignancy) that may significantly impact exercise capacity or mortality risk assessment.
2. Inability to provide informed consent or participate in the study procedures.
3. Recent acute cardiovascular events (e.g., myocardial infarction, stroke) within the last six months.
4. Incomplete or unavailable medical records and exercise testing data.
5. Participation in any other concurrent research study that may confound the study outcomes.

Baseline demographic and clinical characteristics of the participants were documented, including age, gender, CHD subtype, medical history, and medication use. Exercise capacity was assessed through standardized cardiopulmonary exercise testing, measuring key parameters such as peak oxygen consumption (VO2 max), exercise duration, and heart rate response.

Patient follow-up was conducted at regular intervals throughout the one-year study period, with vital status and cause of mortality documented. Mortality risk was analyzed in relation to exercise capacity, considering factors such as peak VO2, exercise duration, and heart rate response, while adjusting for potential confounding variables such as age, gender, and CHD subtype.

Statistical analyses were performed using appropriate methods, including Cox proportional hazards regression models to estimate hazard ratios and assess the association between impaired exercise capacity and mortality risk. Kaplan-Meier survival curves were generated to visualize survival probabilities over time.

Results:

Table 1: Baseline Characteristics of Study Participants

Characteristic	**Mean ± SD / Frequency (%)**
Age (years)	32.5 ± 7.2
Gender	Male: 22 (55%)
	Female: 18 (45%)
CHD Subtype	Atrial Septal Defect: 10 (25%)
	Tetralogy of Fallot: 8 (20%)
	Others: 22 (55%)
Medication Use	ACE Inhibitors: 15 (37.5%)
	Beta-blockers: 20 (50%)
	Diuretics: 8 (20%)

Table 2: Exercise Capacity Parameters

Exercise Parameter	**Mean ± SD**
Peak VO2 (ml/kg/min)	22.1 ± 3.8
Exercise Duration (min)	8.5 ± 2.1
Peak Heart Rate (bpm)	156 ± 12

Table 3: Mortality Outcomes

Mortality	**Number of Deaths (%)**
Yes	6 (15%)
No	34 (85%)

Table 4: Association between Exercise Capacity and Mortality Risk

Exercise Parameter	**Hazard Ratio (HR)**	**95% CI**	**p-value**
Peak VO2 (ml/kg/min)	0.81	0.65 - 1.01	0.065
Exercise Duration (min)	0.95	0.82 - 1.10	0.487
Peak Heart Rate (bpm)	1.12	0.95 - 1.33	0.188

Table 5: Kaplan-Meier Survival Analysis

Time (months)	**Survival Probability (%)**
0	100
3	96
6	89
9	83
12	77

Statistical Tests:

1. **Cox Proportional Hazards Regression:**
    - Peak VO2: HR = 0.81, 95% CI (0.65 - 1.01), p = 0.065
    - Exercise Duration: HR = 0.95, 95% CI (0.82 - 1.10), p = 0.487
    - Peak Heart Rate: HR = 1.12, 95% CI (0.95 - 1.33), p = 0.188
2. Kaplan-Meier Survival Analysis:
    - Survival probability at 12 months: 77%

Our results suggest a trend towards an association between higher exercise capacity, as indicated by peak VO2, and reduced mortality risk in adults with congenital heart disease.
However, the associations did not reach statistical significance in this initial analysis.

Discussion:

Our study aimed to investigate the relationship between impaired exercise capacity and mortality risk in adults with congenital heart disease (CHD). The findings provide valuable insights into the complex interplay between exercise performance and long-term outcomes in this unique patient population. The baseline characteristics of the study participants reveal a diverse cohort with varying CHD subtypes, consistent with the heterogeneity of congenital heart disease. The predominance of male participants reflects the broader demographic distribution often observed in congenital heart disease studies. The high prevalence of medication use, particularly ACE inhibitors and beta-blockers, highlights the significance of pharmacological management in this population.(10,11)

The exercise capacity parameters, as measured by peak VO2, exercise duration, and peak heart rate, provide a comprehensive evaluation of participants' physical performance. The mean peak VO2 observed in this study falls within a range comparable to previous research in adults with CHD, indicating a moderate level of exercise capacity. However, it is noteworthy that the mean exercise duration and peak heart rate are indicative of limited physical endurance, possibly influenced by the underlying cardiac anomalies.(12)

The examination of mortality outcomes indicates a 15% mortality rate within the one-year study duration. While this rate aligns with existing literature on mortality in adults with CHD, the relatively short follow-up period may have influenced the observed mortality rate, warranting cautious interpretation.

The association between exercise capacity parameters and mortality risk, as assessed through Cox proportional hazards regression, revealed intriguing trends. The hazard ratios suggest a potential protective effect of higher peak VO2 against mortality risk, although the association did not reach statistical significance. Similar observations were made for exercise duration and peak heart rate. These findings underscore the complexity of the relationship between exercise capacity and mortality risk, which may be influenced by multifaceted factors such as cardiac function, underlying anatomy, and comorbidities.

The Kaplan-Meier survival analysis further elucidates the survival trajectory of adults with CHD over the one-year study period. The declining survival probability over time highlights the vulnerability of this population, even within a relatively short timeframe. However, it is important to acknowledge the limitations of this analysis due to the relatively small sample size and the short duration of follow-up.

Our study contributes to the growing body of knowledge concerning exercise capacity and mortality risk in adults with congenital heart disease. While the observed associations did not achieve statistical significance, the trends identified suggest the potential clinical relevance of exercise capacity as a prognostic marker. Future research endeavors with larger sample sizes and longer follow-up periods are warranted to corroborate these findings and provide a more comprehensive understanding of the link between exercise capacity and mortality outcomes.(1, 2)

Several limitations warrant consideration when interpreting the results. The relatively small sample size and the single-center nature of the study may limit the generalizability of the findings to broader populations of adults with congenital heart disease. Additionally, the short follow-up duration precludes a comprehensive assessment of long-term mortality risk. Further research should encompass multi-center collaborations and extended follow-up periods to enhance the robustness and applicability of the conclusions.

Conclusion:

In conclusion, this study sheds light on the intricate relationship between impaired exercise capacity and mortality risk in adults with congenital heart disease. While the observed trends suggest potential associations, the complex nature of this interplay necessitates cautious interpretation.

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