Scientific Letters

Oral Communication 1

The social support "Staircase": Decoding neurocognitive phenotypes in acute coronary syndrome via explainable machine learning

Ana Bastos [1], Dulce Sousa [2], Afonso Rocha [3,4], Diana Gonçalves [1], Guilherme Aroso [1], Miguel Peixoto [5,6] and Bruno Peixoto [1,7,8,*]

[1] Department of Social and Behavioral Sciences of University Institute of Health Sciences – CESPU, Gandra, Portugal
[2] Department of Psychology, Unidade Local de Saúde de São João, Porto, Portugal
[3] Cardiocare Research Group, CINTESIS@RISE, Faculty of Medicine, University of Porto, Porto, Portugal
[4] Department of Physical and Rehabilitation Medicine, Unidade Local de Saúde de São João, Porto, Portugal
[5] Psychosocial Rehabilitation Laboratory, Center for Rehabilitation Research (LabRP-CIR), Escola Superior de Saúde, Instituto Politécnico do Porto, Porto, Portugal
[6] Laboratory of Neuropsychophysiology, Faculty of Psychology and Education Sciences, University of Porto, Porto, Portugal
[7] Associate Laboratory i4HB - Institute for Health and Bioeconomy, University Institute of Health Sciences – CESPU, Gandra, Portugal
[8] UCIBIO - Applied Molecular Biosciences Unit, Translational Toxicology Research Laboratory, University Institute of Health Sciences (1H-TOXRUN, IUCS-CESPU), Gandra, Portugal

* Correspondence: bruno.peixoto@iucs.cespu.pt

Abstract

Background: Despite the high prevalence of neurocognitive impairment following Acute Coronary Syndrome (ACS) [1], clinical management often overlooks the heterogeneous nature of these deficits [2]. Identifying distinct neurocognitive phenotypes is essential for personalized rehabilitation [3]. **Objective:** To organize post-ACS neurocognitive profiles using a data-driven pipeline and determine the non-linear predictors of severe impairment. **Methods:** We applied a two-stage machine learning framework to an ACS cohort. First, an unsupervised phase (K-means clustering) was used to discover latent phenotypes based on cognitive performance. Second, a supervised phase compared seven machine learning algorithms to predict phenotype membership. Explainable AI (XAI) tools, including Partial Dependence Plots (PDPs) and probability heat maps, were used to visualize variable interactions. **Results:** Two phenotypes emerged: "Mild/Moderate" (n=231) and "Severe Impairment" (n = 100). XGBoost outperformed all other models (AUC = 0.959; Sensitivity = 99.1%). A robust algorithmic consensus was achieved, with six of the seven models identifying Social Support (ESSS) as the primary predictor. XAI analysis revealed a critical "staircase effect": neurocognitive risk remains high and stagnant until a social support threshold of 35–38 points is reached. Furthermore, high social support was found to exert a "buffering effect", significantly neutralizing the cognitive impact of high depressive symptoms. **Conclusions:** Neurocognitive health post-ACS is not a linear function of clinical severity but a complex interplay of psychosocial resources. The identification of a specific social support threshold (ESSS < 35) provides a concrete clinical marker for identifying patients at risk of severe decline, necessitating a shift toward socially integrated cardiac rehabilitation.

Keywords: acute coronary syndrome; neurocognition; machine learning; social support; depression; phenotyping; *XGBoost*

Acknowledgments/Funding

This research received no external funding.

References

1. Silva, M. et al. Neurocognitive impairment after acute coronary syndrome: Prevalence and characterization in a hospital-based cardiac rehabilitation program sample. *J Cardiovasc Thorac Res* **2018**, *10,* 70-75, doi:10.15171/jcvtr.2018.11.
2. Peixoto, B. et al. Acute coronary syndrome and neurocognition: Determinants and moderators. *Revista Iberoamericana de Neuropsicologia* **2022**, *5*, 1-9.
3. Moreira, I. et al. Predictive model of neurocognitive functioning after acute coronary syndrome. A machine learning approach. *J Cardiovasc Thorac Res* **2025**, *17*, 181-187, doi:10.34172/jcvtr.025.33340.