REVISÃO DE LITERATURA IDENTIFICADO

EVOLUÇÃO NEUROLÓGICA APÓS PARADA CARDÍACA: FISIOPATOLOGIA, CURSO CLÍNICO, PROGNÓSTICO E DESFECHOS A LONGO PRAZO

NEUROLOGICAL EVOLUTION AFTER CARDIAC ARREST: PATHOPHYSIOLOGY, CLINICAL COURSE, PROGNOSTICATION AND LONG-TERM OUTCOMES

Maria Fernanda Rosa[1] João Pedro Cardoso Faccio[2]

1.Acadêmica do curso Medicina da Afya Pato Branco; **2.** Professor do curso Medicina da Afya Pato Branco. Mhafhe26@gmail.com.

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ABSTRACT

Cardiac arrest is a medical emergency associated with high morbidity and mortality. Among patients who achieve return of spontaneous circulation, hypoxic-ischemic brain injury is one of the main causes of death and long-term disability. Cerebral ischemia rapidly causes energy failure, ATP depletion, neuronal depolarization, excitotoxicity, calcium overload, mitochondrial dysfunction, and neuronal injury. After restoration of circulation, reperfusion may further aggravate brain injury through oxidative stress, inflammation, blood-brain barrier dysfunction, cerebral edema, and microcirculatory impairment. The aim of this literature review is to analyze neurological outcomes after cardiac arrest, focusing on the pathophysiology of brain injury, recovery of consciousness, neurological prognostication, and long-term cognitive and functional outcomes. A narrative literature review was conducted using PubMed, prioritizing publications from 2021 to 2025, including international guidelines, a review of post-cardiac arrest brain injury, a neuroprognostication guideline, and a systematic review of long-term cognitive impairment. Current evidence supports a multimodal approach to neurological prognostication, combining clinical examination, electroencephalography, somatosensory evoked potentials, biomarkers, and neuroimaging. Prognostication should also be performed at an appropriate time and after exclusion of potential confounding factors. Therefore, post-cardiac arrest care should extend beyond survival and basic functional independence, incorporating cognitive assessment, rehabilitation, and longitudinal follow-up.

Keywords: cardiac arrest; hypoxic-ischemic brain injury; neurological prognosis; neuroprognostication;

1. INTRODUCTION

Cardiac arrest is characterized by the sudden cessation of effective cardiac mechanical activity, resulting in interruption of systemic and cerebral blood flow. The brain is particularly vulnerable because of its high metabolic demand and limited energy reserves. Consequently,

cerebral ischemia during cardiac arrest rapidly initiates cellular and metabolic processes that may lead to irreversible neuronal injury.[1]

Return of spontaneous circulation is essential for survival but does not necessarily indicate neurological recovery. Post-cardiac arrest brain injury remains an important cause of mortality, coma, disability, and poor quality of life among survivors. The severity of neurological injury depends on factors such as the duration of circulatory interruption, quality of cardiopulmonary resuscitation, time to return of spontaneous circulation, and the patient's clinical condition.[1]

During ischemia, reduced oxygen and glucose availability leads to decreased ATP production and failure of energy-dependent ion pumps. Neuronal depolarization, excessive glutamate release, calcium influx, mitochondrial dysfunction, and oxidative stress contribute to neuronal injury. Reperfusion, although necessary for tissue survival, may further activate inflammatory pathways and increase oxidative damage, cerebral edema, and microvascular dysfunction.[1]

Neurological recovery after cardiac arrest is highly variable. Some patients regain consciousness rapidly, whereas others remain comatose for several days or develop persistent neurological deficits. Sedative medications, neuromuscular blockade, metabolic disturbances, organ dysfunction, and temperature management may interfere with neurological examination and should therefore be considered during prognostic assessment.[2]

The objective of this review is to discuss the pathophysiology of post-cardiac arrest brain injury, the clinical course of recovery of consciousness, current methods of neurological prognostication, and long-term cognitive and functional outcomes.

2. METHODS

A narrative literature review was conducted using the PubMed/MEDLINE database. The search included the terms “cardiac arrest,” “post-cardiac arrest brain injury,” “hypoxic-ischemic brain injury,” “neurological outcome,” “neuroprognostication,” “coma,” and “cognitive impairment.”

Publications from 2021 to 2025 were prioritized, particularly clinical guidelines, scientific reviews, and systematic reviews addressing neurological outcomes after cardiac arrest. Studies focused exclusively on pediatric populations or unrelated to the neurological consequences of cardiac arrest were excluded.

Five references considered most relevant to the objectives of this review were selected for the final analysis.

3. RESULTS AND DISCUSSION

Brain injury after cardiac arrest results from both the initial ischemic insult and secondary mechanisms associated with reperfusion. During cardiac arrest, cessation of cerebral blood flow causes a rapid reduction in oxygen and glucose delivery. ATP depletion leads to failure of membrane ion pumps, neuronal depolarization, glutamate release, and excessive intracellular calcium accumulation.[1]

Calcium overload activates several intracellular pathways that damage cellular membranes, proteins, and genetic material. Mitochondrial dysfunction and increased production of reactive oxygen species contribute to oxidative stress and may activate apoptotic and other cell-death pathways.[1]

Reperfusion may further aggravate the initial injury. The restoration of oxygen delivery can promote oxidative stress and inflammatory activation, while endothelial dysfunction and disruption of the blood-brain barrier may contribute to cerebral edema. Alterations in cerebral microcirculation and autoregulation can also make the injured brain particularly vulnerable to hypotension and abnormalities in oxygenation and ventilation.[1]

Therefore, return of spontaneous circulation should not be considered the end of cerebral injury. The post-cardiac arrest period represents a critical window for preventing secondary neurological damage through appropriate physiological and intensive care management.[1]

3.1 Recovery of Consciousness

Recovery of consciousness varies considerably after cardiac arrest. Persistent coma during the initial period does not necessarily indicate irreversible neurological injury. Sedatives, neuromuscular blocking agents, metabolic abnormalities, organ dysfunction, and temperature management can delay awakening and interfere with neurological examination.[2]

For this reason, neurological prognostication should not be performed prematurely. Current recommendations emphasize adequate observation time and exclusion of confounding factors before establishing a definitive prognosis.[2]

The possibility of delayed awakening is particularly important because premature prognostication may influence decisions regarding continuation or withdrawal of life-sustaining treatment. Prognostic evaluation should therefore be conducted carefully and repeatedly, considering the patient's clinical evolution and all available diagnostic information.[2]

3.2 Neurological Prognostication

Modern neurological prognostication after cardiac arrest is based on a multimodal approach. No single clinical sign, biomarker, electrophysiological test, or imaging finding should generally be used in isolation to determine an individual patient's outcome.[2]

The neurological examination remains essential and includes assessment of consciousness, motor responses, pupillary reflexes, and corneal reflexes. Bilateral absence of the pupillary light reflex at an appropriate time, in the absence of confounding factors, is considered an important predictor of poor neurological outcome. However, clinical findings should be interpreted together with other prognostic modalities.[2]

Electroencephalography provides information regarding cerebral electrical activity and can assist in the detection of seizures and identification of patterns associated with poor neurological outcome. Somatosensory evoked potentials are also valuable, particularly the bilateral absence of the cortical N20 response when appropriately performed and interpreted.[2]

Biomarkers such as neuron-specific enolase may provide additional prognostic information, but their interpretation should consider timing, laboratory methodology, and possible confounding conditions. Neuroimaging can complement the evaluation by demonstrating cerebral edema or patterns of hypoxic-ischemic injury on computed tomography or magnetic resonance imaging.[1,2]

The strength of multimodal prognostication lies in the combination of complementary information. Clinical examination evaluates neurological function, electroencephalography evaluates electrical activity, evoked potentials assess neurophysiological responses, biomarkers provide information related to neuronal injury, and neuroimaging demonstrates structural abnormalities.[1,2]

3.3 Temperature Control and Neuroprotection

Temperature management is an important component of post-cardiac arrest care. Current recommendations emphasize prevention and treatment of fever and individualized temperature management rather than assuming that deep hypothermia is mandatory for every patient.[5]

Neuroprotection also depends on adequate oxygenation, ventilation, and hemodynamic management. Both hypoxia and excessive oxygen exposure may be harmful, while hypotension can compromise cerebral perfusion, particularly when cerebral autoregulation is impaired.[5]

Thus, post-cardiac arrest neuroprotection should be understood as a comprehensive strategy involving temperature control, adequate perfusion, appropriate oxygenation and ventilation, correction of metabolic abnormalities, seizure management, and repeated neurological assessment.[1,5]

3.4 Long-Term Cognitive and Functional Outcomes

Neurological recovery does not necessarily end at hospital discharge. Survivors may develop persistent cognitive, emotional, and functional difficulties despite apparently favorable recovery during hospitalization. A systematic review published in 2023 identified memory impairment as one of the most frequently reported long-term cognitive problems among cardiac arrest survivors.[4]

Other potential difficulties include impaired attention, executive dysfunction, reduced processing speed, fatigue, and problems returning to professional or social activities.[4] These deficits may remain unnoticed when assessment is limited to basic activities of daily living.

Consequently, functional independence should not be considered equivalent to complete neurological recovery. A patient may be physically independent while still experiencing significant difficulties with memory, concentration, planning, or complex occupational tasks.[4]

Long-term follow-up should therefore include assessment of cognitive and psychosocial functioning when clinically indicated. Rehabilitation may involve physical therapy, occupational therapy, speech and language therapy, cognitive rehabilitation, and psychological support, according to the individual patient's needs.[4],[5]

3.5 Quality of Life and Longitudinal Follow-Up

The concept of successful recovery after cardiac arrest has progressively expanded from survival to survival with an acceptable quality of life. Current recommendations emphasize follow-up after hospital discharge and recognition of physical, neurological, cognitive, and psychosocial consequences.[5]

Longitudinal care is particularly important because some deficits become more evident when patients attempt to return to work, education, family responsibilities, or other complex activities. Early identification of cognitive and functional difficulties may allow appropriate rehabilitation and improve reintegration into daily life.

Family members and caregivers should also be considered as part of the post-cardiac arrest care process. The consequences of a severe neurological injury can affect the entire family and may generate prolonged physical, emotional, and social demands.[5]

4. CONCLUSION

Neurological outcomes after cardiac arrest are determined by the interaction between the initial cerebral ischemic injury and secondary mechanisms occurring after reperfusion. ATP depletion, excitotoxicity, calcium overload, mitochondrial dysfunction, oxidative stress, inflammation, cerebral edema, and microcirculatory disturbances contribute to the progression of brain injury.[1]

Neurological prognostication should be performed at an appropriate time and through a multimodal strategy. Clinical examination, electroencephalography, somatosensory evoked potentials, biomarkers, and neuroimaging provide complementary information and should be interpreted collectively. Premature prognostication or reliance on a single marker may increase the risk of inaccurate conclusions.[2]

Long-term recovery should also be considered because cognitive impairment, particularly involving memory, as well as fatigue and psychosocial difficulties, may persist after hospital discharge.[4] Therefore, assessment of cardiac arrest survivors should extend beyond mortality and basic functional independence.

In conclusion, post-cardiac arrest care should be understood as a continuous process beginning with prevention of secondary brain injury during the acute phase and extending through neurological follow-up and rehabilitation after discharge. The ultimate goal should not only be survival but also the best possible neurological, cognitive, functional, and psychosocial recovery.[5]

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