Acute Cardiac Complications in Critical Brain Disease

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KEYWORDS

• Acute cardiac complications • Acute critical brain disease • Neurogenic stunned myocardium • Stress cardiomyopathy • Acute critical brain injury

KEY POINTS

- Acute cardiac complications in acute critical brain disease should be understood as a clinical condition representing an intense brain-heart crosstalk and might mimic ischemic heart disease.
- Two main entities (neurogenic stunned myocardium [NSM] and stress cardiomyopathy) have been better characterized in the neurocritically ill patients and they portend worse clinical outcomes in these cases.
- The pathophysiology of NSM remains elusive.
- However early identification of neurocardiac compromise is now feasible in the setting critical brain disease.
- Effective prevention and treatment interventions are yet to be determined.

INTRODUCTION: BRAIN-HEART INTERACTION

Brain-heart connections have been documented for decades.[1] Described in late nineteenth century, the Cushing reflex (bradycardia and hypertension due to increased intracranial pressure) is a remarkable example of this highly regulated interaction.[2] Indeed, the nervous and cardiovascular systems are highly interconnected in both healthy conditions (eg, baroreceptor reflex) and diseases. There is an increasing relevance to this communication as the mechanisms behind this brain-heart network have been better characterized. A specialty focused in brain-heart interactions has thus emerged and is referred to as neurocardiology.[3] This medical field studies the brain-heart pathophysiologic interplay.[4] Hence, the role of this specialty has been conceptualized into 3 main categories: the effect of the heart on the brain, the effect of the brain on the heart, and neurocardiac syndromes.[5]

Cardiac complications following neurologic injuries are associated with higher morbidity and mortality.[6] Some of these abnormalities include hypotension, cardiogenic shock, clinical heart failure, arrhythmias, electrocardiographic (ECG) changes, release of biomarkers as surrogates of cardiac injury, and regional wall motion abnormalities (RWMAs).[6] Fortunately, these phenomena and clinical signs are usually reversible, and cardiac mortality is relatively low, but not zero, and the treatment is focused on general supportive care and primary management of the brain injury.[6]

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The primary aim of this article was to revisit the evidence behind cardiac dysfunction after most common neurologic injuries. We highlight the pathophysiology advancements in cardiovascular complications among patients with specific neurologic disorders. Future directions of research in this topic are also considered.

STRESS-INDUCED CARDIOMYOPATHY VERSUS NEUROGENIC STUNNED MYOCARDIUM

Cardiac injury through brain-heart network interactions is distinct depending on the primary insult. Two separate entities have been recognized: stress cardiomyopathy (SCM) and neurogenic stunned myocardium (NSM).[7] SCM, now most commonly referred to as Takotsubo cardiomyopathy,[8] but also broken heart syndrome,[9] or ampulla-shaped cardiomyopathy,[10] is characterized by transient midsegmental left ventricular (LV) dysfunction with or without apical involvement.[11] Classic clinical findings include chest pain, ECG changes, transient LV wall motion abnormalities, and elevation in myocardial enzymes without evidence of epicardial coronary artery disease.[12] It usually occurs in combination with a stressful event.[11] Hence, multiple triggers have been identified.[13] Usually, SCM portends a good short-term prognosis with full recovery of the LV function. This entity is more prevalent in female patients, especially in postmenopause phase.[14]

In contrast to SCM, cardiac injury resulting from a primary neurologic condition has been commonly referred to as NSM.[15] It is typically recognized as basal or mid LV regional motion abnormalities[16] following subarachnoid hemorrhage (SAH)[15] or stroke.[17] Other conditions associated with this clinical entity include seizures,[18] traumatic brain injury (TBI),[19] hydrocephalus,[20] intracerebral hemorrhage, and Guillain-Barre syndrome.[21] Likewise, NSM usually has a favorable prognosis with recovery rates varying from 66% to 78% in a 2-week period in comparison with 92.3% in SCM.[22] Despite this comparable favorable prognosis, in-hospital mortality has been described up to 5% to 8% during the acute phase, which is similar to the reported mortality for a myocardial infarction with elevated ST segment.[23–26] Furthermore, late mortality after hospital discharge has been found to be higher than in age-matched patient healthy populations.[27]

Whether SCM and NSM are different presentations of a common pathophysiologic pathway or represent 2 different clinical entities remains unknown.[28] Given the pathophysiologic and clinical presentation similarity between SCM and NSM, a revision of the diagnostic criteria has been suggested.[14] Although similar, there is some evidence that the clinical presentation, ECG changes, and LV RWMAs might differ.[29] A recent publication of patients with NSM and SCM further highlights these differences.[30] Characteristics of both clinical conditions are presented in **Table 1**.

PATHOPHYSIOLOGY OF CARDIOVASCULAR DYSFUNCTION AFTER NEUROLOGIC ILLNESS

Brain-Heart Axis: A Highly Regulated Interaction

The neurocardiac axis comprises multiple interconnected areas in the brain.[31,32] This highly regulated network sustains a fine balance between the sympathetic and parasympathetic autonomic systems.[31,32] The understanding of this network homeostasis is crucial for further recognition of pathophysiologic cardiac events occurring in neurocritically ill patients.[33]

Supramedullary regions of the cardiac regulation system

The insula and specific portions of the hypothalamus are considered the origin of the autonomic outflow.[34] The insula is located in the cerebral cortex and controls the parasympathetic and sympathetic outflow from the neurocardiac axis.[34] A chronotropic map of the insular cortex has been previously described in rat models.[35,36] Moreover, the sympathetic and parasympathetic systems are regulated by the right and left insular cortex, respectively.[35–37] Patients with middle cerebral artery acute ischemic stroke (AIS) and subsequent injury of the insular cortex are prone to abrupt cardiovascular variations and sudden cardiac death.[38]

The main autonomic outflow is originated from the hypothalamus (lateral hypothalamus area and paraventricular and dorsomedial nucleus).[31] Lateral hypothalamic stimulation induces tachycardia and ST-segment depression, whereas anterior hypothalamic stimulation causes bradycardia.[39] Moreover, there is evidence of ECG changes and myocardial necrosis induced solely by hypothalamic stimulation.[39]

Following the craniocaudal projections of the neurocardiac axis, the integrated autonomic responses in the midbrain occur in the periaqueductal gray substance.[31,32] This structure lies interconnected within the solitary nucleus (rostral brainstem) and regulates baroreflex and cardiac reflexes (first central relay of medullary reflexes, which also receives pulmonary efferents).[40]