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NEUROGENIC STUNNED MYOCARDIUM: A CASE REPORT AND BRIEF REVIEW

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□ **Abstract—Background: Neurogenic stunned myocardium (NSM) is a condition in a group of stress cardiomyopathies with evolving nomenclature that includes Takotsubo cardiomyopathy. It manifests through electrocardiogram changes, cardiac enzyme elevation, and regional or global kinetic wall motion abnormalities. Case Report: We present a 43-year-old female with a subarachnoid hemorrhage who developed persistent hypotension and tachycardia secondary to neurogenic stress cardiomyopathy. Why Should an Emergency Physician Be Aware of This?: It is important to consider NSM in any patient with neurologic pathology and undifferentiated shock. Early recognition in the emergency department setting can yield valuable data to guide the treatment and improve clinical outcomes in these patients. Published by Elsevier Inc.**

□ **Keywords—stunned myocardium; subarachnoid hemorrhage; cardiogenic shock**

INTRODUCTION

We present the case of a 43-year-old female with a subarachnoid hemorrhage (SAH) who developed persistent hypotension and tachycardia secondary to neurogenic stunned myocardium (NSM). NSM often presents within hours after an initial neurologic injury, and is associated with an increased risk for all-cause mortality (1,2). There is a growing body of literature supporting brain–heart crosstalk after neurologic insults. Pathophysiologic mechanisms indicate typical catecholamine-based vasopressor agents may have decreased efficacy in this disease process. Awareness of this brain–heart connection may help hasten identification and shorten time to appropriate interventions (1,2).

NSM is a condition in a group of neurogenic stress cardiomyopathies with evolving nomenclature that includes Takotsubo cardiomyopathy (1). Although some authors use the titles interchangeably, it is believed by many that these are separate entities based on the location of abnormal wall motion, specifically the apex in Takotsubos and mid-base in NSM (1). It manifests through electrocardiogram (ECG) changes, cardiac enzyme elevation, and regional or global kinetic wall motion abnormalities (1). SAH is the most common etiology of NSM, but it can occur after traumatic brain injury, ischemic stroke, hemorrhagic stroke, seizures, central nervous system infection, or any markedly stressful event (1). The resulting decrease in cardiac output can lead to secondary neurologic injury due to decreased cerebral perfusion pressures. Specific epidemiologic data are limited, but several case series have reported an incidence of 8–30% in SAH and 1.2% in ischemic stroke (3,4). NSM usually coincides with neurogenic pulmonary edema (NPE). NPE is an increase in pulmonary interstitial and alveolar fluid secondary to acute central nervous system injury. NPE is a clinical diagnosis with the presentation of pulmonary edema after neurologic insult and in the absence of a more likely alternative cause (5).

Although further research is still needed to identify which patients are at highest risk for cardiovascular complications from neurologic insults, some have suggested a higher incidence in those with insular involvement, right-

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sided stroke, history of hypertension, coronary artery disease, and those with intense emotional stress (6). Female gender has also been listed as a risk factor in some studies (3). Neurocardiogenic injury is associated with a significant increase in all-cause mortality, cardiac mortality, and heart failure (2).

There are several proposed pathophysiologic mechanisms, including aborted myocardial infarction with spontaneous coronary thrombus lysis, transient multivessel coronary artery spasm, microvascular dysfunction, and the catecholamine hypothesis (1,7,8). The catecholamine hypothesis proposes that an acute injury to the brain results in an autonomic storm with sympathetic hypertonia. This leads to excessive $\beta 1$ and $\beta 2$ stimulation, with the potential for additional $\alpha 2$ modulation (1,9,10). Increased levels of interstitial myocardial norepinephrine lead to myocyte calcium overload and subsequent cell death. This cell death appears as "myocardial contraction band necrosis" with death occurring in the contracted state. In contrast, ischemic disease causes cell death in a relaxed state (11).

CASE REPORT

Our patient was an otherwise healthy 43-year-old female who stood up quickly at work and had a sudden-onset severe headache. A few moments afterward, she collapsed to the ground. On arrival of Emergency Medical Services, her Glasgow Coma Scale score was 4 with normal glucose and stable vital signs. She was intubated and transported to the emergency department (ED). On initial evaluation in the ED, she withdrew to painful stimuli and was otherwise unresponsive. Pupils were sluggish but reactive and equal. She had spontaneous respiratory effort and maintained a cough, gag, and corneal reflexes. She had no reported medical, surgical, social, or family history. Laboratory workup revealed normal complete blood count, basic metabolic panel, human chorionic gonadotropin, coagulation studies, and a troponin of 0.08 ng/mL. Computed tomography (CT) imaging revealed a severe SAH and intracranial cerebral aneurysm (Figure 1), consistent with a Hunt and Hess 4/5 and a Fisher grade 4 (12). The patient had significant improvement in neurologic function and began to move all extremities spontaneously after the placement of an external ventricular drain by neurosurgery. Her heart rate started to slowly rise from 80 beats/min on arrival to 120 beats/min, and she was progressively hypotensive at or below 80/40 mm Hg. Her extremities remained warm, but her urine output was low. There were no other obvious injuries, source of infection, or evidence of a thrombotic cause. Her ECG (Figure 2) revealed a borderline prolonged QT interval but was otherwise normal. Chest radiograph (Figure 3) with mild cephalization and subsequent CT imaging (Figure 4) revealed progressive pulmonary edema consistent with NPE. Formal echocardiogram revealed an ejection fraction (EF) of 26% with diffuse left ventricular mid-section wall motion abnormalities and no evidence of left ventricular outflow tract obstruction. Initial central venous oxygen saturation ($ScVO_2$) obtained via a central line was 62%. Upon transfer to the intensive care unit, a dobutamine infusion was started without a significant change in blood pressure. However, the dobutamine administration resulted in a worsening tachycardia and increased ectopy. Both blood pressure and heart rate were improved after a decrease in the dobutamine infusion and the initiation of norepinephrine. A follow-up $ScVO_2$ was 78%, suggesting improved cardiac output. A repeat bedside echocardiogram revealed an EF of 45%. The patient's 8-h troponin was

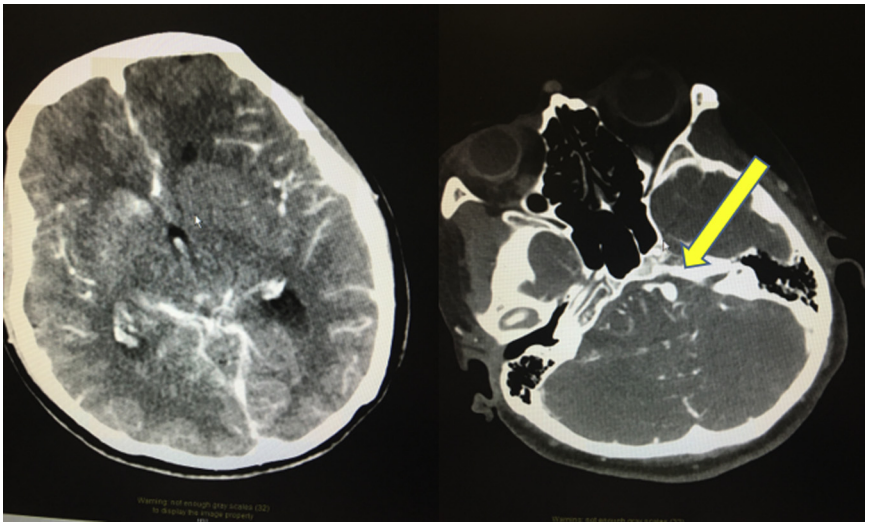

Figure 1. Left significant diffuse subarachnoid hemorrhage. Right internal carotid aneurysm (yellow arrow).

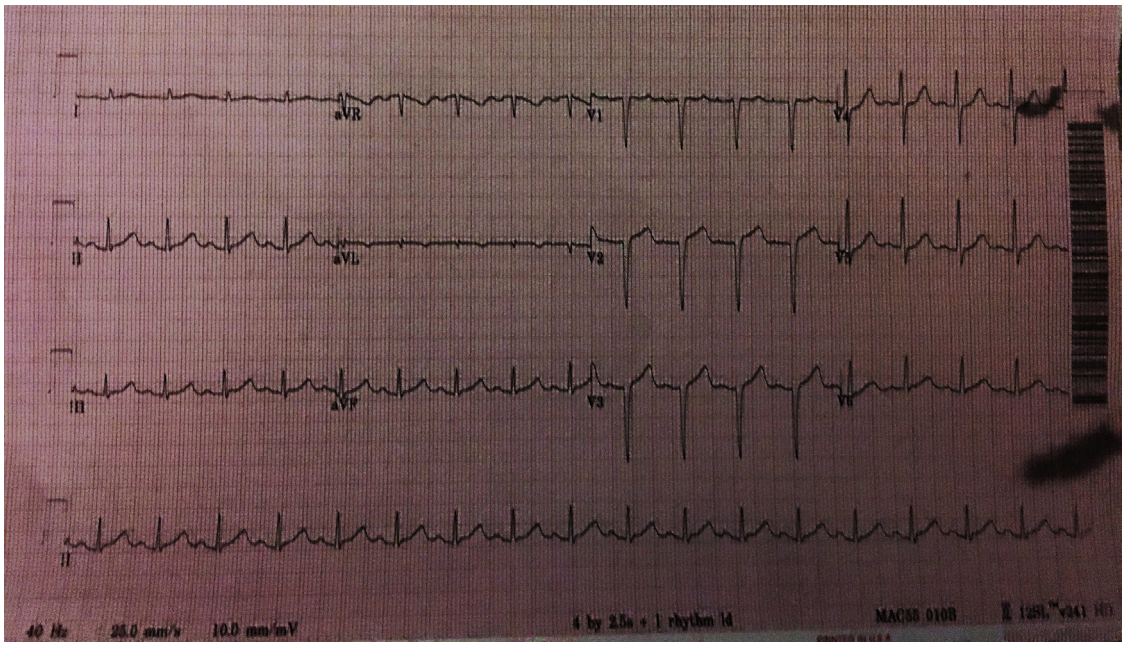

Figure 2. Electrocardiogram revealing a borderline prolonged QT interval.

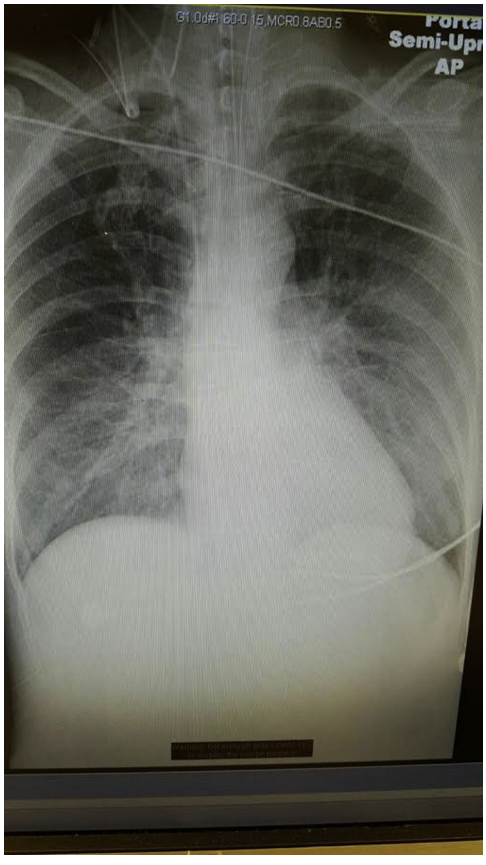

Figure 3. Chest x-ray study with mild hilar prominence and cephalization of vessels.

4.5 ng/mL and peaked 16 h later at 7.5 ng/mL. She was extubated on day 3, but required persistent dual vasopressor support for 6 days. Neurologic status was later compromised during the hospital course by a left medullary cerebrovascular accident, thought to be iatrogenic secondary to an angiogram and aneurysmal coiling. Her neurologic status later improved to baseline, and she was discharged 4 weeks after initial presentation.

DISCUSSION

This case highlights several essential characteristics of NSM, including typical presentation, course, treatment challenges, and reversibility. ECG findings are present in 25–75% of SAH patients and include Q-T prolongation, T-wave inversions, supraventricular and ventricular dysrhythmias (1). Our patient's ECG had a borderline QTc at 485 ms but was otherwise unremarkable. Pro-BNP is often markedly elevated in patients with NSM. Troponin I is a sensitive and specific marker of myocardial injury associated with neurologic insults, though at times this can be difficult to distinguish from MI (1). Obtaining an echocardiogram can help with this distinction. It is important to consider further cardiac workup if wall motion abnormalities follow a vascular distribution.

In general, regional or global wall motion abnormalities are present in 8–13% of SAH patients (1). A mid-region echocardiographic abnormality is typical of NSM and thought to be related to the greater sympathetic innervation

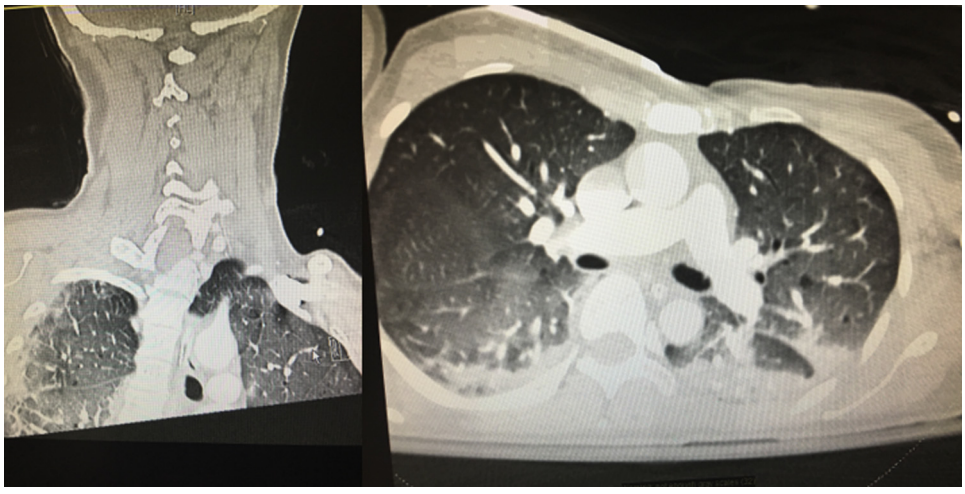

Figure 4. Computed tomography scan with increased pulmonary edema.

of the mid and basal segments vs. a more significant proportion of $\beta 2$ receptors in the apex (1). This is most often a reversible wall motion abnormality beyond any vascular territory (11). Our patient followed the typical disease progression, which involves wall motion abnormalities arising within 1–2 days of initial neurologic insult and a gradual improvement over the following 3–8 days (1).

Studies have suggested a higher incidence of NSM in those with insular involvement (6). The insular cortex contains both inhibitory and excitatory sympathetic baroreceptive units that regulate blood pressure and heart rate. Injury of the insula gives rise to changes in these cardiovascular parameters and has been found to result in the surge of norepinephrine levels in the blood that cause left ventricular dysfunction (13,14). Stimulation of the right insula elicited sympathetic effects like tachycardia and hypertension in human epileptic patients. In the same study, stimulation of the left insula resulted in parasympathetic responses, such as bradycardia and vasodepressor effects (15).

Treatment of NSM is mainly supportive and directed at life-threatening events, such as dysrhythmias and cardiogenic shock. This can be complicated by a left ventricular outflow tract obstruction due to a hyperdynamic basal segment, pulmonary edema, and poor response to typical vasopressor agents. Such cases may require an intra-aortic balloon pump during the acute phase (1).

NPE differs from other causes of respiratory failure with regard to ventilator management in that special consideration must be given to intracranial pressures. Permissive hypercapnia can cause cerebral vasodilation, thereby increasing cerebral blood flow and potentially increasing intracranial pressures. High levels of positive end-expiratory pressure may be needed due to pulmonary edema, but this can reduce cerebral venous return and worsen intracranial hypertension (5).

The use of β-blockers in the treatment of SAH in the prevention of NSM is unclear, further research is needed. Liang et al. showed that pre-admission β-blockers are associated with decreased risk of developing NSM in patients with SAH (16). A retrospective study of 691 patients with aneurysmal NSM showed that preadmission β-blocker does not decrease the incidence of mortality, cardiac dysfunction, or cerebral vasospasm in patients with SAH (17).

Lastly, a left ventricular thrombus is of particular concern when the apical segment is involved, and anticoagulation should be considered when able (1). The Neurocritical Care Society Consensus on patients with SAH promotes screening for cardiac involvement with a baseline troponin and ECG (1). Transthoracic echocardiography is recommended if either is abnormal.

WHY SHOULD AN EMERGENCY PHYSICIAN BE AWARE OF THIS?

Emergency physicians should be aware of the possibility of NSM. It is important to consider in any patient with neurologic pathology and undifferentiated shock. Early recognition in the ED setting can yield valuable data to guide therapy and improve outcomes in these patients.

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