Variant Neurogenic Stunned Myocardium in a Young Female After Subarachnoid Hemorrhage

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Neurogenic stunned myocardium is a significant complication of subarachnoid hemorrhage. Diagnosis of neurogenic stunned myocardium is complicated by variable presentation. We present a case of a 23-year-old woman admitted with a subarachnoid hemorrhage from an arteriovenous malformation and associated aneurysm. Postoperatively, she developed pulmonary edema and mildly elevated cardiac biomarkers. Echocardiography showed hypokinesis of the basal left ventricular segments and normal contraction of the apical left ventricular segments consistent with a variant form of neurogenic stunned myocardium. We describe characteristics and outcomes of neurogenic stunned myocardium in this young patient with arteriovenous malformation-associated aneurysmal subarachnoid hemorrhage. (A&A Case Reports. 2016;6:10–3.)

Transient left ventricular dysfunction after subarachnoid hemorrhage is well documented. It is a form of stress cardiomyopathy and has been called numerous terms over the years, including takotsubo cardiomyopathy,[1] apical ballooning syndrome, neurogenic stress cardiomyopathy,[2] and neurogenic stunned myocardium.[3] Traditionally, it is characterized by transient dyskinesis of the left ventricular apex in a myocardial distribution covered by more than 1 coronary artery.[3,4] There is a reported 1.2% to 5.6% prevalence of this complication after subarachnoid hemorrhage.[5–7] A variant or inverse form in which the mid or basal left ventricular segments are dysfunctional and apical left ventricular segment contraction is preserved was first described in 2005 and has since been increasingly reported.[8–10]

We report a variant of neurogenic stunned myocardium in a patient with an arteriovenous malformation-associated aneurysmal subarachnoid hemorrhage and review epidemiology and outcomes of both types of neurogenic stunned myocardium in patients with subarachnoid hemorrhage.

The patient could not be contacted and University of Florida's IRB has determined that review and approval are unnecessary.

CASE DESCRIPTION

A 23-year-old woman presented within 24 hours of a sudden-onset severe headache, left facial droop, and left extremity weakness. Her medical history was significant only for tobacco use and infrequent injection of oxycodone for 1 year.

She presented with a Glasgow Coma Score of 15, left-sided homonymous hemianopsia, central left facial palsy, decreased sensation and strength in the left upper and lower extremities, a positive Babinski sign on the left, and a Hunt Hess score of 3. At the time of admission, her cardiovascular examination, electrocardiogram (Fig. 1), and chest radiograph were within normal limits. Computed tomography of the head showed a right-sided temporoparietal hemorrhage of 4 × 1.5 cm, 6 mm of right to left subfalcine herniation, and subarachnoid blood. A subsequent cerebral angiogram showed a complex arteriovenous malformation along the right lateral ventricle fed by the right anterior and posterior choroidal arteries, with an associated anterior choroidal aneurysm.

The patient underwent staged embolization of the arteriovenous malformation. On hospital day 8, the patient underwent angiogram with Onyx® liquid embolization of the aneurysm. During this procedure, she developed occlusion of the distal right internal carotid artery by Onyx embolic liquid material, causing ischemia of the proximal middle cerebral artery distribution. Over the following 24 hours, she developed further hemorrhage and herniation and underwent a decompressive craniectomy and evacuation of the hematoma.

Her postoperative course was complicated by increased intracranial pressure and sudden decrease in arterial blood pressure requiring intravascular volume resuscitation and administration of multiple vasopressors and inotropes, including phenylephrine, epinephrine, and vasopressin. She developed pulmonary edema, requiring endotracheal intubation and mechanical ventilation. Invasive hemodynamic monitoring demonstrated depressed cardiac output. Her cardiac biomarkers were mildly elevated (troponin-T 0.57, creatinine kinase 43, CK-MB 17.9, and CK-MB index of 3.7). Twelve-lead electrocardiogram showed sinus tachycardia with no ST-T wave changes (Fig. 2). Echocardiogram showed a heart with

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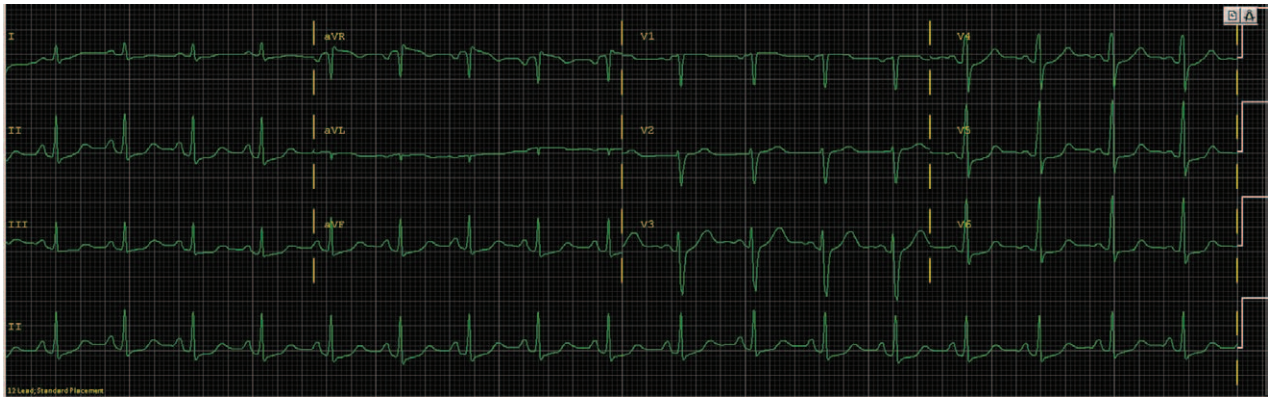

Figure 1. Preoperative electrocardiogram showing sinus tachycardia and a corrected QT (QTc) of 455 milliseconds.

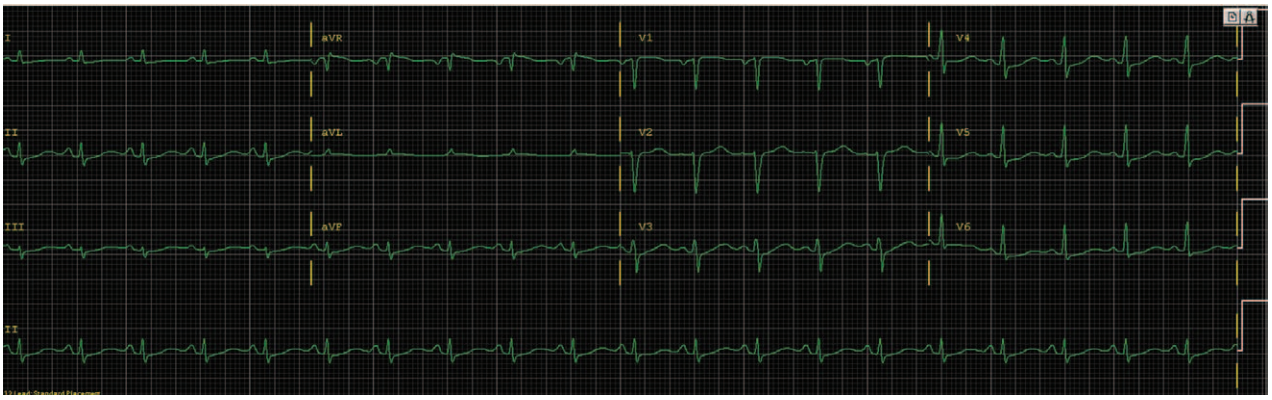

Figure 2. Postoperative electrocardiogram during episode of hypotension and development of pulmonary edema showing sinus tachycardia, lower voltage than previous, and slightly longer corrected QT (QTc) of 475 milliseconds.

normal chamber size and moderate left ventricular dysfunction with severe circumferential basal hypokinesis and hyperkinetic apical segments (Fig. 3, Video 1, Supplemental Digital Content 1, http://links.lww.com/AACR/A19). The ejection fraction was 25% to 30%. The right ventricle showed normal ventricular systolic function.

The patient was diagnosed with variant neurogenic stunned myocardium and supportive therapy was initiated with inotropes, diuresis, and airway pressure release ventilation. Over the subsequent 9 days, the patient's cardiac status gradually improved and she was weaned from inotropic support. Repeat echocardiograms showed significant improvement in left ventricular systolic function (Video 2, Supplemental Digital Content 2, http://links.lww.com/AACR/A20). On day 30, her ejection fraction was more than 55% with only minimal residual hypokinesis of the inferior and inferoseptal segments. Six months later, she returned for cranioplasty with no residual cardiopulmonary abnormalities and only mild left-sided weakness. At 1-year follow-up, her echocardiogram showed normal left and right ventricular systolic function.

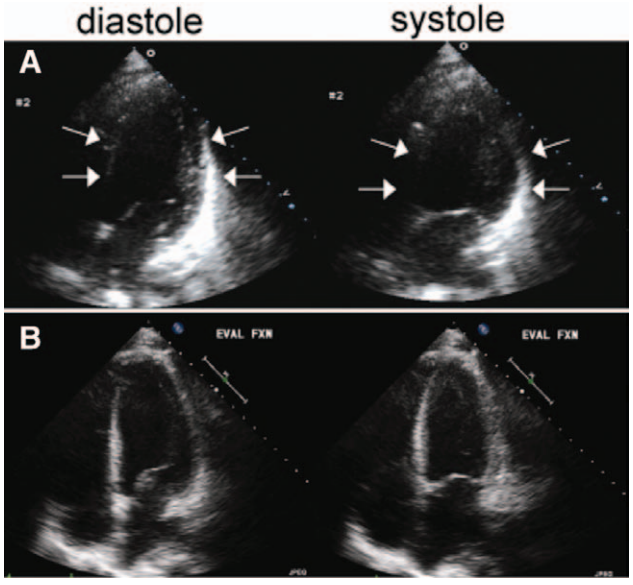

Figure 3. Echocardiogram of inverted neurogenic stunned myocardium. A, An apical view of the left ventricle shows basal ballooning during systole in the acute period. B, An apical view 13 days later shows recovery with uniform contraction of the left ventricle.

DISCUSSION

Neurogenic stunned myocardium is a significant complication of subarachnoid hemorrhage. It may be underrecognized because both diagnosis and treatment are challenging. In the neurosurgical intensive care unit, more than 70% of patients with subarachnoid hemorrhage will develop some type of cardiac abnormality.[11,12] In patients with subarachnoid hemorrhage, when cardiomyopathy is incorrectly presumed to be caused by an acute coronary syndrome, additional morbidity

can occur with anticoagulation and the definitive treatment of subarachnoid hemorrhage can be delayed.[6,13] Moreover, the occurrence of neurogenic stunned myocardium may further complicate management of vasospasm after subarachnoid hemorrhage because hemodynamic augmentation cannot only be difficult, but the use of vasopressors may further worsen cardiac dysfunction. Hence, a timely diagnosis of both classic and variant forms of neurogenic stunned myocardium is important to ensure appropriate care.

There are 66 cases of subarachnoid hemorrhage-induced neurogenic stunned myocardium reported in the literature (Table, Supplemental Digital Content 3, http://links.lww.com/AACR/A21). Consideration of subarachnoid hemorrhage as a cause of stress cardiomyopathy is important because treatment of subarachnoid hemorrhage was delayed in 23 patients while the nature of their cardiomyopathy was evaluated. Twelve of these patients died in the hospital. As a group, patients with subarachnoid hemorrhage-induced stress cardiomyopathy are diverse, but they have many common features (Table 1). Like classical stress cardiomyopathy, subarachnoid hemorrhage-induced cardiomyopathies have a striking predominance in women (85%) with a mean age of 57 years (Table 1). Among these, all but 6 showed changes on electrocardiogram and mildly elevated cardiac biomarkers (3 cases do not have this information available). Twenty-seven patients underwent coronary angiography; only 2 were found to have coronary artery disease, which was deemed insufficient to have caused the cardiomyopathy. By recognizing that middle-aged women with electrocardiographic changes and elevated cardiac biomarkers are at risk of neurogenic stunned myocardium, early diagnosis of neurogenic stunned myocardium can be made and morbidity from delay in treating the subarachnoid hemorrhage can be avoided.

Almost three-fourths of patients had the classical apical dyskinesis form of neurogenic stunned myocardium. The rest had a variant form. Of the variant forms, most had inverted, basal akinesis, and the rest had diffuse and mid-ventricular dyskinesis. The abnormalities in apical left ventricular function have been quantified in patients with subarachnoid hemorrhage and the classical form of neurogenic stunned myocardium.[2] However, regional systolic function in patients with variant forms of neurogenic stunned myocardium has not yet been quantified with measures of wall motion, wall thickening, or myocardial strain. Additionally, subarachnoid hemorrhage leads to abnormalities in diastolic left ventricular function irrespective of obvious abnormalities of left ventricular systolic function.[14] In patients with subarachnoid hemorrhage, it remains unclear which pattern of systolic or diastolic dysfunction has the greatest impact on overall left ventricular function.

Even among the small number of reported cases, our patient seems to be an outlier. Her heart failure occurred after the embolization procedure when she developed further hemorrhage and elevated intracranial pressure. She is one of the 4 patients who exhibited no changes on electrocardiogram. Her diagnosis was made after evidence of pulmonary edema, which made an echocardiogram necessary. The echocardiogram showed basal hypokinesis consistent with variant neurogenic stunned myocardium. Neurogenic stunned myocardium was an unexpected diagnosis given her young age. Excluding the rare pediatric patient,[15–17] there are fewer than 10 reported cases of women younger than 40 years old with stress cardiomyopathy. Our patient is the only reported case of arteriovenous malformation-associated neurogenic stunned myocardium and the first woman in her 20s reported in the literature in whom subarachnoid hemorrhage-induced neurogenic stunned myocardium was present.

Table 1. Summary of Characteristics of Published Cases of Neurogenic Stunned Myocardium

Variables	Value
Age (years), mean (SD)	57 (13)
Females, *n* (%)	57 (85)
Comorbid conditions, *n* (%)	
Coronary artery disease	2 (3)
Diabetes mellitus	3 (4)
Hypertension	13 (19)
Clinical presentation, *n* (%)	
Altered mental status	54 (81)
Headache	36 (54)
Chest pain	7 (10)
Severe bleeding (Fisher > 3 or HH ≥ 3)	50 (75)
Echocardiogram changes, *n* (%)	
T wave abnormalities	40 (60)
ST segment changes	45 (67)
QT interval prolongation	20 (30)
Cardiac enzyme elevation	44 (66)
Stress cardiomyopathy classification, *n* (%)	
Classical	49 (73)
Variant, inverted	10 (15)
Variant, diffuse	3 (7)
Variant, mid	4 (9)
Initial ejection fraction %, mean (SD)	31 (10)
Follow-up ejection fraction %, mean (SD)	59 (7)
Coronary angiogram performed, *n* (%)	27 (40)
Aneurysm treatment delayed, *n* (%)	23 (34)
Treatment of aneurysm, *n* (%)	
Microvascular clipping	18 (27)
Endovascular coiling	25 (37)
No surgical treatment	14 (21)
Hospital mortality, *n* (%)	20 (30)

This table summarizes the 66 cases of neurogenic stunned myocardium in patients with subarachnoid hemorrhage reported in the literature.

HH = Hunt-Hess.

Kampine JP, Stowe DF, Pagel PS. Cardiovascular anatomy and physiology. In: Barash et al., eds. Clinical Anesthesia, 6th ed. Philadelphia: Lippincott, Williams and Wilkins, 2009:217.

The most widely accepted mechanism for stress cardiomyopathy is an exaggerated sympathetic response of the myocardium to catecholamines released into the circulation or from sympathetic neurons directly onto the myocardium.[18,19] However, there may be different mechanisms for the different forms of stress cardiomyopathy.[20] In subarachnoid hemorrhage, elevated plasma catecholamines may be secondary to hypothalamic and nucleus tractus solitarius damage[7,21] and correspond to elevated cardiac biomarkers.[22] Estrogen may play a protective role for cardiac myocytes against catecholamine toxicity. This could explain why the majority of susceptible patients are postmenopausal women.[23] However, it does not explain the occurrence of neurogenic stunned myocardium in our patient. Although measuring catecholamine levels in patients with subarachnoid hemorrhage and heart failure may support the diagnosis of neurogenic stunned myocardium, the clinical utility of this approach has not been systematically studied. Why some patients have the

classical apical ballooning and others have a variant form is unknown. No correlation between patient presentation, characteristics, and subtype of neurogenic stunned myocardium has been identified.[24] It has been speculated that there could be variances in the anatomic location and susceptibility of cardiac adrenergic receptors to catecholamine surges during times of stress, receptor polymorphism, or due to the degree of sympathetic activity.[10]

There is no standard treatment for subarachnoid hemorrhage-induced neurogenic stunned myocardium. Because the condition is transient, supportive care is the mainstay. A recent animal study points to the possibility of α-1 blockade to prevent injury, whereas β blockade may worsen it.[21] However, a recent retrospective clinical study showed preadmission β blockade decreases the incidence of neurogenic stunned myocardium in aneurysmal subarachnoid hemorrhage,[25] leading to the continued debate and controversy over whether either α or β blockade may prevent myocardial injury.[26,27] Should these patients require hemodynamic support, noncatacholamine inotropic or vasopresssor therapy, such as milrinone or vasopressin, may be preferred.[28] In survivors, close follow-up with a repeat electrocardiogram and echocardiogram is necessary to document complete resolution of heart function.

In conclusion, to aid in better recognition of neurogenic stunned myocardium in the neurosurgical intensive care unit, we presented a unique case of a young woman with a variant neurogenic stunned myocardium precipitated by subarachnoid hemorrhage in association with a complex arteriovenous malformation and aneurysm. Although rare, this case highlights the variability in stress cardiomyopathy, including neurogenic stunned myocardium. Stress cardiomyopathy should be diagnosed early to avoid the morbidity and mortality associated with inappropriate interventions and not delay treatment of subarachnoid hemorrhage.

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