Intracranial Hemorrhage in Patients with a Left Ventricular Assist Device

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■ BACKGROUND: **There is a dearth of literature regarding management and outcomes of patients with a left ventricular assist device (LVAD) for advanced heart failure who develop intracranial hemorrhage (ICH). We conducted a case series from 2 centers highlighting patient outcomes and prognostic factors to help clinicians better understand and care for these high-risk patients.**

■ METHODS: **A case series from 2 large-volume institutions (defined as large by the Nationwide Inpatient Sample hospital size, i.e., >500 beds both with Departments of Neurosurgery and Advanced Heart Failure—Cardiology) was conducted to clarify the prognosis of patients with an LVAD and ICH. We included patients who were being treated with an LVAD who developed ICH. Patient-specific demographics and data regarding heart failure and intracranial hemorrhage characteristics were collected and analyzed to determine which factors contributed to overall survival.**

■ RESULTS: **We analyzed 59 unique ICHs in patients being treated with an LVAD for heart failure. Initial Glasgow Coma Scale score, presence of midline shift, and ICH size were factors found to be predictive of mortality. One institution had a sicker patient population including patients with ICH with lower Glasgow Coma Scale score, presence of midline shift, and greater hemorrhage size, which led to overall higher mortality compared with the second institution.**

■ CONCLUSIONS: **Patients being treated with an LVAD who develop ICH have poor outcomes. Predictive factors for same-admission mortality are lower initial Glasgow Coma Scale score, presence of midline shift, and greater ICH volume.**

INTRODUCTION

Left ventricular assist devices (LVADs) used as both transplantation and destination therapy have been shown to improve survival, secondary organ function, and nutritional status as well as reduce pulmonary hypertension in patients with advanced heart failure.[1] LVAD technology has evolved, and use of LVADs by cardiologists has significantly increased with patients being referred for evaluation and implantation more often and earlier in the course of the disease.[1] Patients with LVADs who develop intracranial hemorrhage (ICH) pose an especially challenging situation for treating physicians. Not only do these patients have several comorbidities in addition to advanced heart failure, but also LVAD therapy necessitates the use of anticoagulation, which puts patients who develop ICH at risk for rapid hematoma expansion. Treating clinicians must balance the risks of reversing anticoagulation to control hematoma expansion with preventing possible LVAD thrombosis. Although the risk of hemorrhagic stroke is low, 0.05–0.31 events/patient-year in a 2012 meta-analysis,[2] patient outcomes remain poor owing to hemorrhagic impact (e.g., level of consciousness, midline shift) and other contributing medical comorbidities.

Keywords
- Intracerebral hemorrhage
- Left ventricular assist device
- Predictive factors

Abbreviations and Acronyms
CT: Computed tomography
GCS: Glasgow Coma Scale
HFH: Henry Ford Hospital
ICH: Intracranial hemorrhage
INR: International normalized ratio
LVAD: Left ventricular assist device
MRI: Magnetic resonance imaging
mRS: Modified Rankin Scale
SAH: Subarachnoid hemorrhage
UAB: University of Alabama at Birmingham

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Stroke as a whole, whether ischemic or hemorrhagic, has been strongly associated with in-hospital mortality, with ischemic events having nearly twice the incidence of hemorrhagic events,[3] but the latter having higher adjusted odds ratios for mortality.[4]

Wilson et al.[5] reported 30-day mortality rates of 59% for patients with LVADs who developed an intraparenchymal hemorrhage. Their study concluded that the only predictive factor in patient outcome was the initial Glasgow Coma Scale (GCS) score. As there are a limited number of cases available to evaluate the prognosis of patients with LVADs and ICH (in 1 institution alone), we performed a study with cases from 2 high-volume tertiary care centers both with Departments of Neurosurgery and Advanced Heart Failure—Cardiology to better understand predictive factors involved in overall outcomes of these complex, critically ill patients.

MATERIALS AND METHODS

This retrospective case series from 2 centers was approved by the institutional review boards of Henry Ford Hospital (HFH) and the University of Alabama at Birmingham (UAB). The LVAD registry of patients at both institutions was screened for *International Classification of Diseases, Ninth Revision*, codes for "intracranial hemorrhage," "subarachnoid hemorrhage," "subdural hematoma," "epidural hematoma," and "intraparenchymal hemorrhage." Patients with ischemic stroke, vasculitis, and spinal hemorrhage and/or hematoma were excluded. Demographic characteristics, including age at time of ICH, race, and comorbid conditions, and ICH characteristics were collected. Factors contributing to overall patient outcomes, including whether hemorrhage led directly to mortality (determined by whether the patient was eventually discharged from the hospital or died during the same admission) and modified Rankin Scale (mRS) score at 30-day follow-up and 3-month follow-up from hospital discharge, were statistically analyzed. As a final outcome, patients were censored at the time of heart transplant.

ICH Volume

The size of the ICH was calculated using a three-dimensional volumetric analysis applied to the initial computed tomography (CT) scan whenever possible to provide greater accuracy compared with traditional volumetric calculations using an ellipsoid model.[6] The ellipsoid model calculates the volume of the hemorrhage based on 3 separate measurements taken in the largest anteroposterior, mediolateral dimension on the CT scan and in the height dimension and dividing the product by 2. Both anteroposterior and mediolateral measurements were in centimeters, and the height was calculated by multiplying the thickness of each CT slice by the number of slices showing hemorrhage.

Data Analysis

To compare patients with ICH who were discharged with patients who died in the hospital, χ^2 tests were used for categorical variables, and *t* tests were used for continuous variables. Fisher exact test was used for categorical variables that did not have expected counts of at least 5 in each contingency table cell. For continuous variables that did not exhibit a normal distribution, the Wilcoxon

Table 1. Patient Demographics

Factor	Number of Patients (%)
Race	
Black	27 (45.8%)
White	32 (54.2%)
Age, years, mean	54.3
Sex	
Male	40 (67.8%)
Female	19 (32.2%)
BMI, mean	28.5
Diabetes mellitus	22 (37.3%)
Hypertension	48 (81.4%)
Smoking	23 (39.0%)
LDL, mg/dL, mean	75.5
Antiplatelet therapy	56 (95.0%)
Anticoagulation therapy	56 (95.0%)
Statin therapy	30 (50.8%)
History of prior stroke	18 (30.5%)
History of GIB	18 (30.5%)

BMI, body mass index; LDL, low-density lipoprotein; GIB, gastrointestinal bleed.

Table 2. Heart Failure Characteristics

Factor	Number of Patients
Type of cardiomyopathy	
Ischemic	23
Nonischemic	34
Type of therapy	
Destination	33
Bridge	21
Days on LVAD at time of hemorrhage, mean	469.8
Age at LVAD placement, years, mean	52.8
Choice of anticoagulation	
Coumadin	52
Other	7
Type of LVAD	
HeartMate II	39
HeartWare HD	8
Other	7

LVAD, left ventricular assist device.