

Effect of Center Volume on Outcomes in Hospitalized Patients With Hereditary Hemorrhagic Telangiectasia

Vivek N. Iyer, MD, MPH; Waleed Brinjikji, MD; Bibek S. Pannu, MBBS; Dinesh R. Apala, MBBS; Giuseppe Lanzino, MD; Harry J. Cloft, MD, PhD; Sanjay Misra, MD; Michael J. Krowka, MD; Christopher P. Wood, MD; and Karen L. Swanson, MD

Abstract

Objective: To determine whether hospitalized patients with hereditary hemorrhagic telangiectasia (HHT) had better outcomes at high-volume treatment centers (HVCs).

Patients and Methods: The Nationwide Inpatient Sample (2000-2011) was used to identify HHT-related hospitalizations. Hospitals were classified based on quartiles of annual HHT discharge volume. The 75th percentile cutoff value (third quartile) was used to classify hospitals as low-volume centers (1-7 HHT discharges per year) or as HVCs (≥ 8 discharges per year). Demographic features, complication rates, and outcomes were compared between the 2 groups.

Results: We identified 9440 hospital discharges in patients with HHT. Of these patients, 6856 (72.6%) were admitted to low-volume centers and 2584 (27.4%) to HVCs. The former were more likely to be of white race, older, and with higher income levels ($P < .001$ for each). The HVCs had higher rates of anemia, epistaxis, congestive heart failure, pulmonary hypertension, and cerebral and pulmonary arteriovenous malformations and lower rates of ischemic stroke and myocardial infarction. After adjusting for baseline differences in a multivariate model, patients treated at HVCs were more likely to be discharged home (odds ratio [OR]=1.35; 95% CI, 1.21-1.52; $P < .001$) and less likely to be discharged to short-term rehabilitation facilities (OR=0.45; 95% CI, 0.31-0.64; $P < .001$). Patients treated at HVCs also had a significantly lower risk of in-hospital mortality (OR=0.51; 95% CI, 0.34-0.74; $P < .001$).

Conclusion: Patients with HHT hospitalized at HVCs had better outcomes, with lower in-hospital mortality and higher home discharge rates. These findings strongly support ongoing efforts to expand access to HHT centers of excellence in the United States and worldwide.

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Hereditary hemorrhagic telangiectasia (HHT) is a rare autosomal-dominant vascular disorder characterized by the presence of large and small arteriovenous malformations (AVMs) in a variety of vascular beds. Hereditary hemorrhagic telangiectasia has an estimated prevalence of 1 in 5000 to 1 in 10,000 individuals and is diagnosed using the Curacao criteria.¹ Although HHT is seen in all races and regions of the world, there is a general lack of awareness among health care providers regarding its cardinal features and complications.^{2,3} In a survey of 233 patients with HHT, a 15-year diagnostic delay was noted from symptom onset to eventual referral

to an HHT center and a 25-year delay between symptom onset and confirmatory diagnosis of HHT.² Only approximately one-third of patients received the correct diagnosis at the time of first counseling, and 10% of patients experienced a severe HHT-related complication from the time of symptom onset to eventual diagnosis.² Similarly, Latino et al³ explored HHT underdiagnosis in Ontario province, Canada, and found that patients with HHT with epistaxis had consulted with an ear, nose, and throat physician for a mean \pm SD of 13.9 ± 12.2 years before eventual diagnosis.

Given the large number of patients with HHT in the United States and worldwide, it



From the Division of Pulmonary and Critical Care Medicine (V.N.I., B.S.P., D.R.A., M.J.K.), Department of Radiology (W.B., H.J.C., S.M., C.P.W.), and Department of Neurosurgery (G.L.), Mayo Clinic, Rochester, MN; and Division of Pulmonary and Critical Care Medicine, Mayo Clinic, Scottsdale, AZ (K.L.S.).

is likely that a substantial fraction of patients receive care from providers and facilities with limited HHT knowledge and expertise.^{2,4} Currently there is lack of evidence to show that treatment in high-volume HHT centers (HVCs) confers any significant benefits in terms of morbidity, mortality, and complication rates. We sought to answer these questions by analyzing a large nationwide sample of hospitalized patients with HHT treated in the United States to detect differences in characteristics and outcomes of patients treated at HVCs vs low-volume HHT treatment centers (LVCs).

METHODS

Patient Population

Using the Nationwide Inpatient Sample (NIS) data from January 1, 2000, through December 31, 2011, we identified all patients with a discharge diagnosis (primary or secondary) of HHT (*International Classification of Diseases, Ninth Revision*, diagnosis code of 448.0). The NIS is a large administrative database that contains a yearly record of 20% of all discharges (randomly selected) from all nonfederal hospitals in the United States. Data for approximately 7 to 8 million hospital discharges are recorded in the NIS annually. Each individual hospitalization is assigned 1 primary discharge diagnosis code and up to 24 distinct secondary diagnosis codes. Similarly, procedural codes for up to 15 distinct types of procedures performed during any individual hospitalization are also recorded.⁵ Detailed information about the NIS is available at <https://www.hcup-us.ahrq.gov/databases.jsp>.

Classification of HHT Treatment Centers

The NIS database allows for estimation of the number of annual HHT discharges per facility. We divided hospital facilities based on quartiles of annual HHT hospital discharge volumes. The 75th percentile was used to classify hospitals as HVCs or LVCs based on the annual number of discharges in patients with HHT. Using this definition, facilities with 1 to 7 HHT discharges annually were classified as LVCs and those with 8 or more HHT-related discharges per year were considered HVCs. A separate analysis was also performed for HVCs and LVCs based on the

90th percentile cutoff value, with 13 or fewer HHT discharges per year classified as LVC^{90th}. Demographic features, complication rates, and outcomes (as detailed later herein) were then compared between LVCs and HVCs for both the 75th and 90th percentile cutoff points. Hospitals were also classified based on geographic location (Northeast, Midwest, South, or West), rural vs urban location, and teaching vs nonteaching status.

Demographic and Baseline Patient Characteristics

Age was categorized into 4 groups: younger than 18, 18 to 50, 51 to 64, and 65 years or older; race was categorized as white, black, Hispanic, and Asian exactly as recorded in the NIS database. Baseline comorbidities studied included smoking status, presence of hypertension, presence of diabetes mellitus, and Charlson comorbidity index (CCI). The CCI is a validated prognostic index for administrative use that has been shown to be predictive of 10-year mortality.⁶

Complications and Outcomes Studied

Complications were divided into hemorrhagic, cardiopulmonary, neurologic, and hepatobiliary related. We also studied procedural utilization and outcomes, which included in-hospital mortality, discharge location (home, short-term care facility vs long-term care facility), hospital length of stay (LOS), and rates of iatrogenic complications for LVCs and HVCs.

Statistical Analyses

All categorical variables are summarized using frequency (percentage) and were compared using a χ^2 test. All continuous variables are summarized using mean \pm SD and were compared using a *t* test. Multivariate logistic regression analysis was performed to determine whether center volume was independently associated with in-hospital outcomes. A standard least squares regression analysis was used to evaluate continuous variables, such as LOS. Variables adjusted for in this model were those that were found to be statistically significant between groups (age, income quartile, race, hypertension, hemorrhagic complications, cardiopulmonary complications, and CCI). We also performed a sensitivity analysis using the 90th percentile of

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