Improved mortality in treatment of patients with endovascular interventions for chronic mesenteric ischemia

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ABSTRACT

Objective: Chronic mesenteric ischemia (CMI) continues to be a devastating diagnosis. There is a national trend toward increased use of endovascular procedures with improved survival for the treatment of these patients. Our aim was to evaluate whether this trend has changed CMI patients' length of hospitalization and health care cost.

Methods: We identified all patients admitted for CMI from the National Inpatient Sample (NIS) from 2000 to 2014. Our primary end points included length of hospital stay (LOS) and cost of hospitalization (COH). Our secondary end points included mortality assessment of the CMI hospitalization.

Results: There were 15,475 patients admitted for CMI. The mean age of patients was 71 years, and 4022 (26.0%) were male. There were 10,920 (70.6%) patients treated endovascularly (ENDO) and 4555 (29.4%) patients treated in an open fashion (OPEN). Although a higher proportion of patients in the ENDO (43.3%) group vs OPEN (33.1%) had a Charlson Comorbidity Index score of ≥2 ($P < .0001$), they had a lower mortality rate (2.4% vs 8.7%; $P < .0001$), lower mean LOS (6.3 vs 14.0 days; $P < .0001$), and lower COH ($21,686 vs $42,974; $P < .0001$). After adjusting for clinical and hospital factors, OPEN continued to demonstrate higher mortality than ENDO (odds ratio, 7.2; 95% confidence interval, 4.9-10.6; $P < .0001$), longer LOS (mean, +9.7 days; $P < .0001$), and higher COH (mean, +$25,834; $P < .0001$).

Conclusions: The rate of ENDO continues to rise nationally in the treatment of CMI patients. After adjusting for clinical and hospital factors, patients in the ENDO group tend to have lower in-hospital mortality of 2.4% and lower LOS by 10 days, and they incur a cost saving of >$25,000 compared with patients in the OPEN group. ENDO should be considered first line of therapy for patients with CMI. (J Vasc Surg 2018;■:1-8.)

Symptomatic chronic mesenteric ischemia (CMI) is uncommon. In a few small series and population studies, it has been shown that it has a relatively low prevalence of 0.03%, possibly because of the large collateral network circulation.[1-5] The main cause of CMI is atherosclerosis (>90%); however, other causes include vasculitis (eg, Takayasu arteritis, polyarteritis nodosa, giant cell arteritis) and fibromuscular dysplasia.[6-8] Once the diagnosis has been established, the goals of therapy are symptom relief and prevention of future acute ischemic events.[9,10] Open mesenteric bypass had been regarded as the "gold standard" for patients with symptomatic CMI. However, morbidity of 5% to 30% and mortality of 2% to 12% associated with open revascularization have prompted the evolution of treatment of this population of severely ill patients in an endovascular fashion.[11-13] Schermerhorn et al,[14] in 2009, were able to demonstrate the value and significance of endovascular procedures in the treatment of CMI during the period 1988 to 2006. They noticed a steady increase of endovascular interventions during their study period, which surpassed the open treatment modality in the year 2002. Furthermore, the mortality improved with endovascular interventions compared with open bypass (3.7% vs 13%). Our study sought to investigate whether this trend regarding the use of endovascular procedures for the treatment of CMI continues to be demonstrated nationally since the last review and whether this paradigm change can be also translated into a shorter length of hospitalization and therefore cost saving in the current era.

METHODS

The Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample (NIS) was used as the data set for this study. The NIS represents the largest all-payer publicly available data set in the United States, containing >10 million discharges annually across the United States.[15] All investigators with access to the data

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R.A.J. is partially supported by CTSA Grant No. TL1 TR001864 from the National Center for Advancing Translational Sciences, a component of the National Institutes of Health. This publication and its contents are solely the responsibility of the authors and do not necessarily represent the official view of the National Institutes of Health.

Author conflict of interest: none.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

https://doi.org/10.1016/j.jvs.2017.10.071

have completed online training and certified Data Use Agreements with HCUP. This study includes completely deidentified data, and it was approved as exempt from review by the Yale Human Investigations Committee (Institutional Review Board ID#2000020859). Therefore, informed consent was not obtained from participants.

Selection of patients. The NIS includes deidentified patient information at the level of unique hospital discharges, with up to 30 *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) diagnosis codes and 15 ICD-9-CM procedural codes. Patients were selected by having a primary diagnosis code for CMI (ICD-9-CM 557.1) between the years 2000 and 2014. Next, we queried discharges for those with procedural codes for open surgical intervention (OPEN), including embolectomy (ICD-9-CM 38.06), endarterectomy (ICD-9-CM 38.10 or 38.16), and bypass (ICD-9-CM 38.36, 39.26, or 38.46). Remaining discharges were queried for a procedural code for endovascular procedures (ENDO), including angioplasty (ICD-9-CM 39.50) and stenting (ICD-9-CM 39.90). Discharged patients were excluded if they had a diagnosis code for aortic aneurysm or dissection (ICD-9-CM 441.X), were younger than 18 years, had procedural dates that occurred before hospitalization, or were missing information (sex, routine discharge, or in-hospital death). The patient's age, sex, and race were fit into categorical variables to facilitate analysis. Age was classified in accordance with the distribution of the study cohort into age groups of 18 to 50 years, 51 to 64 years, 65 to 80 years, and older than 81 years. To account for the impact of the patient's comorbidity, the Deyo adaptation of the Charlson Comorbidity Index (CCI) was used to group patients into three comorbidity classes: CCI 0, CCI 1, and CCI ≥2. Comorbidities were identified by querying discharges for a predefined set of ICD-9-CM diagnosis codes.[16] Hospitals were classified according to U.S. census region as Northeast, Midwest, South, or West. Hospitals were also classified by location as urban or rural and by teaching status.

Given the variation in presentation for CMI, discharges were queried for variables that may have predicted for acute ischemic rather than for chronic disease. To account for overlap in diagnosis codes between chronic and acute mesenteric ischemia, the presence of a secondary diagnosis code for acute mesenteric ischemia (ICD-9-CM 557.0) and procedural evidence of small or large bowel resection (ICD-9-CM 45.6X, 45.90, 45.91, or 46.7X) were used as exclusion criteria.

Primary and secondary end points. Primary end points included length of stay (LOS) and cost of hospitalization (COH). Our secondary end point was in-hospital mortality. The NIS includes hospital charges, which were converted to approximate costs using cost-to-charge ratio files provided by HCUP. Hospital-specific cost-to-charge ratios are calculated for each year of the database, using administrative hospital accounting reports collected by the Centers for Medicare and Medicaid Services.[17] All costs were adjusted to 2014 U.S. dollars using the National Bureau of Labor Statistics inflation calculators.[18]

Statistical analysis. All final analyses and calculations were performed using complex survey methods to account for the stratified cluster sample design of the NIS. Each discharge in the NIS is provided with an associated discharge weight, which allows estimates to be nationally representative. In 2012, the NIS was redesigned from a 20% stratified sample of U.S. hospitals to a sample of discharges nationally.[19] To account for differences in the hospital sampling frame in calculating trends, HCUP has provided Trend Weight Files for years before 2012, which were used in our analysis. Differences between groups were tested using χ^2 test for categorical variables and Student *t*-test and Wilcoxon rank sum test for the normally distributed and non-normally distributed continuous variables, respectively. Because of the use of discharge weights, median LOSs were not necessary integer values and were rounded to the nearest integer to facilitate interpretation. Univariable and multivariable linear and logistic regressions were used to identify the impact of unadjusted and adjusted confounders on outcome variables. Statistical significance was set at a *P* value of .05. All statistical analysis was performed using SAS version 9.4 (SAS Institute, Cary, NC).

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected data from the National Inpatient Sample (NIS)
- **Take Home Message:** Endovascular treatment in 70.6% of 15,475 patients with chronic mesenteric ischemia resulted in a significantly lower mortality rate (2.4% vs 8.7%), shorter length of hospitalization (6.3 vs 14 days), and lower costs of hospitalization compared with open revascularization.
- **Recommendation:** This study suggests that endovascular procedures should be first-line therapy for chronic mesenteric ischemia because it is less costly, results in shorter hospitalizations, and has less risk of mortality compared with open surgical revascularization.

RESULTS

There were 15,475 patients treated for CMI during 2000 to 2014. There were 4022 (26.0%) male patients and 11,349 (74.0%) female patients with a mean age of 71 years. The majority of patients were in the age group 51 to