

From the Society for Clinical Vascular Surgery

Preoperative dementia is associated with increased cost and complications after vascular surgery

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ABSTRACT

Objective: Dementia represents a major risk factor for medical complications and has been linked to higher rates of complication after surgery. Given the systemic nature of vascular disease, medical comorbidities significantly increase cost and complications after vascular surgery. We hypothesize that the presence of dementia is an independent predictor of increased postoperative complications and higher health care costs after vascular surgery.

Methods: The Vascular Quality Initiative database was queried for all patients undergoing vascular surgery at a single academic medical center from 2012 to 2017. All modules were included (open abdominal aortic aneurysm, suprainguinal bypass, lower extremity bypass, amputation, carotid endarterectomy, endovascular aortic aneurysm repair, thoracic endovascular aortic aneurysm repair, and peripheral endovascular intervention). An institutional clinical data repository was queried to identify patients with *International Classification of Diseases, Ninth Revision* diagnosis codes for dementia as well as total hospital cost and long-term survival using Social Security records from the Virginia Department of Health. Hierarchical logistic and linear regression models were fit to assess risk-adjusted predictors of any complication and inflation-adjusted cost. Kaplan-Meier and Cox proportional hazards models were used for survival analysis.

Results: A total of 2318 patients underwent vascular surgery and were captured by the Vascular Quality Initiative during the past 5 years, with 88 (3.8%) having a diagnosis of dementia. Patients with dementia were older and had higher rates of medical comorbidities, and the most common procedure was major amputation. In addition, dementia patients had a significantly higher rate of any complication (52% vs 16%; $P < .0001$) and increased 90-day mortality (14% vs 4.8%; $P = .0002$). Furthermore, dementia was associated with significant resource utilization, including preoperative length of stay (LOS), postoperative LOS, intensive care unit LOS, and inflation-adjusted total hospital cost (all $P < .0001$). Hierarchical modeling demonstrated that dementia was the strongest preoperative predictor for any complication (odds ratio, 8.64; $P < .0001$) and had the largest risk-adjusted impact on total hospital cost (\$22,069; $P < .0001$). Finally, survival analysis demonstrated that dementia is independently associated with reduced survival after vascular surgery (hazard ratio, 1.37; $P = .018$).

Conclusions: This study demonstrated that dementia is one of the strongest predictors of any complication and increased hospital cost after vascular surgery. Given the high risk of clinical and financial maladies, patients with dementia should be carefully considered and counseled before undergoing vascular surgery. (J Vasc Surg 2018;■:1-6.)

Keywords: VQI; Dementia; Outcomes; Cost; Futility

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Significant medical advances and the growing elderly population have led to more patients undergoing major vascular surgery at older ages with higher rates of medical comorbidities.¹ Numerous studies have sought to identify the strongest predictors of complication rates and poor outcomes after vascular surgery. These efforts have proved fruitful to allow better risk stratification and counseling of patients.² The Vascular Quality Initiative (VQI) has developed from this work to collect standardized demographic, comorbid, operative, and postoperative data of patients undergoing vascular interventions, with success in improving outcomes for patients.³ However, preoperative dementia remains a significant and underappreciated risk factor in vascular surgery patients that is not routinely collected in most quality databases.

A prospective study by Partridge et al¹ found that 68% of patients older than 60 years admitted to vascular

surgery had some level of cognitive impairment, with 88% of these patients having no previously documented evidence of dysfunction. Furthermore, several studies have highlighted the significant impact of dementia and cognitive dysfunction on outcomes after orthopedic surgery as well as the significantly increased incidence of postoperative delirium.^{4,5} These complications have major implications for resource utilization and long-term survival of affected patients after most major operative procedures. Specifically, the vascular surgery population is susceptible to these problems, given the chronic nature of their disease processes and the systemic effects of vascular disease, resulting in high rates of comorbid medical conditions.

The purpose of this study was to evaluate the risk-adjusted association of preoperative dementia diagnosis on outcomes, inflation-adjusted cost, and long-term survival of patients undergoing vascular surgery procedures. It is hypothesized that dementia may be associated with increased rates of risk-adjusted complications and inflation-adjusted hospital cost.

METHODS

All patients undergoing vascular surgery at a single academic medical center from 2012 to 2017 were evaluated. The patients' records were obtained through an institutional VQI database using all modules (open abdominal aortic aneurysm, suprainguinal bypass, lower extremity bypass, amputation, carotid endarterectomy, endovascular aortic aneurysm repair, thoracic endovascular aortic aneurysm repair, and peripheral endovascular intervention) as previously described.^{6,7} Standard VQI definitions were used for each comorbidity and complication as previously reported.^{2,3,8,9} An institutional clinical data repository was used to collect actual hospital cost, payor status, long-term survival (using Social Security records), and *International Classification of Diseases, Ninth Revision* (ICD-9) codes for dementia (290, 290.0, 290.1, 290.10, 290.11, 290.12, 290.13, 290.2, 290.20, 290.21, 290.3, 290.4, 290.40, 290.41, 290.42, 290.43, 290.8, 290.9, 294.1, 294.10, 294.11, 294.2, 294.20, 294.21). Records for each patient were merged from these sources using the medical record and Social Security number. The Centers for Medicare and Medicaid Services Inpatient Prospective Payment System medical service-specific inflation adjustment was used for hospital costs.

Categorical variables were presented as number (percentage); all continuous variables, except cost, were presented as median (interquartile range), given the non-normal distribution of the data. Univariate analysis employed nonparametric tests to compare characteristics of patients with preoperative dementia and those without. Multivariate hierarchical logistic, linear, and Cox proportional hazards models were used to assess risk-adjusted outcomes for

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected Vascular Quality Initiative registry data
- **Take Home Message:** Preoperative dementia was identified in 3.8% of 2308 patients undergoing a vascular procedure and was associated with higher complication rates, higher costs, and increased 90-day mortality (14% vs 4.8%).
- **Recommendation:** This study suggests that preoperative dementia should be identified and considered a risk factor for mortality and complications after vascular procedures.

complications, cost, and survival, respectively. Procedure was used as a fixed effect to appropriately determine the impact of each covariate on the outcome of interest while controlling for the risk attributed to the procedure. The decision was made a priori to include the most significant predictors from univariate analysis up to a total of 1 predictor for every 10 events in the model. Statistical significance was set to α of 10.05. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC). The University of Virginia Institutional Review Board approved this study with waiver of consent because of the retrospective nature of the data collection (Protocol #17900).

RESULTS

A total of 2318 consecutive patients underwent vascular surgery at our institution during the past 5 years who were captured by the VQI database. Of these, only 88 (3.6%) had an ICD-9 diagnosis of dementia. Patients with dementia were significantly more likely to be older (74 vs 66 years; $P < .0001$), with less independent ambulatory status (81% vs 91%; $P < .0001$) and higher incidence of end-stage renal disease (15% vs 4.8%; $P < .0001$) as well as American Society of Anesthesiologists (ASA) classification >3 (39% vs 16%; $P < .0001$). Furthermore, patients with dementia were more likely to have government insurance (90% vs 72%; $P = .001$) and to have a longer preoperative hospital length of stay (LOS; 1 day vs 0 days; $P < .0001$). Stratified by operation, major amputation was the most common procedure in patients with dementia, whereas open abdominal aortic aneurysm repair was the least common (Table I).

Patients with a diagnosis of dementia had significantly worse outcomes including higher rates of any complication (52% vs 16%; $P < .0001$) and 90-day mortality (14% vs 4.8%; $P = .0002$; Table II). However, there was no statistical difference in 30-day mortality (4.6% vs 2.7%; $P = .29$). Importantly, resource utilization was significantly higher in patients with dementia, including longer hospital LOS (7 days vs 3 days;

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