Preventable Complications Driving Rising Costs in Management of Patients with Critical Limb Ischemia

Anahita Dua,[1] Sapan S. Desai,[2] Bhavin Patel,[3] Gary R. Seabrook,[1] Kellie R. Brown,[1] Brian Lewis,[1] Peter J. Rossi,[1] Michael Malinowski,[1] and Cheong J. Lee,[1] Milwaukee, Wisconsin; Springfield, Illinois; New York

Background: This study aimed to identify factors that drive increasing health-care costs associated with the management of critical limb ischemia in elective inpatients.

Methods: Patients with a primary diagnosis code of critical limb ischemia (CLI) were identified from the 2001−2011 Nationwide Inpatient Sample. Demographics, CLI management, comorbidities, complications (bleeding, surgical site infection [SSI]), length of stay, and median in-hospital costs were reviewed. Statistical analysis was completed using Students' *t*-test and Mann-Kendall trend analysis. Costs are reported in 2011 US dollars corrected using the consumer price index.

Results: From 2001 to 2011, there were a total of 451,823 patients who underwent open elective revascularization as inpatients for CLI. Costs to treat CLI increased by 63% ($12,560 in 2001 to $20,517 in 2011, $P < 0.001$ in trend analysis). Endovascular interventions were 20% more expensive compared with open surgery ($19,566 vs. $16,337, $P < 0.001$). Age, gender, and insurance status did not affect the cost of care. From 2001 to 2011, the number of patient comorbidities (7.56−12.40) and percentage of endovascular cases (13.4% to 27.4%) increased, accounting for a 6% annual increase in total cost despite decreased median length of stay (6 to 5 days). Patients who developed SSI had total costs 83% greater than patients without SSIs ($30,949 vs. $16,939; $P < 0.001$). Patients who developed bleeding complications had total costs 41% greater than nonbleeding patients ($23,779 vs. $16,821, $P < 0.001$). Overall, there was a 32% reduction in SSI rates but unchanged rates of bleeding complications during this period.

Conclusions: The cost of CLI treatment is increasing and driven by rising endovascular use, SSI, and bleeding in the in-patient population. Further efforts to reduce complications in this patient population may contribute to a reduction in health care−associated costs of treating CLI.

INTRODUCTION

The US currently spends up to 20% of its gross domestic product on health care−related costs.[1] In just over 4 decades, the United States had gone from spending $75 billion annually to a projected $4 trillion by 2015 on direct health care costs; this upward trend is unsustainable in the long term.[1] Hence, hospital administrators and health care providers alike have been challenged with reducing costs associated with their patient populations.

Critical limb ischemia (CLI) management costs the US health care system $10 to $20 billion annually.[2] This figure is only projected to increase as the aging population rises given that 1% of people older than 50 years and 2% of those older than 70

Oral presentation (plenary) at the 38th Annual Meeting of the Midwestern Vascular Surgical Society, Coralville, IA, September 4−6, 2014.

No conflicts of interest or disclosures.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

[1]Department of Surgery, Medical College of Wisconsin, Milwaukee, WI.

[2]Department of Vascular Surgery, Southern Illinois University, Springfield, IL.

[3]Department of General Internal Medicine, North Shore Long Island Jewish Health System, New Hyde Park, NY.

Correspondence to: Anahita Dua, MD, MS, MBA, Department of Surgery, Medical College of Wisconsin, 8701 Watertown Plank Road, Milwaukee, WI 53226, USA; E-mail: andua@mcw.edu

Ann Vasc Surg 2016; 33: 144–148
http://dx.doi.org/10.1016/j.avsg.2015.11.026

Manuscript received: April 19, 2015; manuscript accepted: November 22, 2015; published online: February 23, 2016.

years have CLI.[2,3] The increasing cost of care coupled with the rising aging population in the United States will result in a societal burden of CLI-associated health care costs that will be tremendous.[4]

Although it is known that costs associated with CLI are increasing, there is a paucity of literature examining specific cost-driving factors in the treatment of CLI inpatients which may be targeted for improvement. This study aimed to evaluate cost-related trends associated with the in-hospital management of CLI patients over the past decade to identify factors that impact overall cost.

METHODS

Database and Selection

A retrospective analysis was completed using the Nationwide Inpatient Sample (NIS), a part of the Health Care Utilization Project that is maintained by the Agency for Healthcare Research and Quality.[5] The NIS is the largest all-payer inpatient database and includes a stratified 20% random sample of all nonfederal inpatient hospital admissions throughout the United States.[5] Clinical records between 2001 and 2011 were derived using the ninth revision of the International Classification of Diseases (ICD-9) diagnosis and procedure codes to include inpatients with peripheral vascular disease who underwent elective treatment primarily for CLI via an open or endovascular approach. Patients who had an emergent procedure or who underwent primary amputations without any revascularization attempts were excluded from the analysis. ICD-9 codes were used to identify diagnosis (440.22 rest pain, 440.23 nonhealing ulcer, 440.24 gangrene), procedure type (00.45–00.48, 39.90 percutaneous angioplasty and stent placement; 39.50 percutaneous angioplasty or atherectomy; 39.29, 39.25 peripheral bypass; 39.56, 39.57 open atherectomy with patch angioplasty). Emergent procedure was defined as a specific flag in the NIS (elective versus nonelective). For the purposes of cost analysis, hybrid procedures and staged procedures were excluded (total population eliminated was 1.5%).

Variables

The independent variable was year, ranging from 2001 to 2011. Demographic covariates included age, gender, and race. Clinical covariates included patient comorbidities, endovascular versus open procedure, complications including surgical site infection (SSI) and bleeding requiring return to the operating room, median length of stay (LOS), and median hospital costs adjusted for 2015 US dollars using the consumer price index. Cost is represented as total hospital cost and is in real dollars adjusted for inflation through the utilization of the consumer price index. All dollars are presented as 2015 US dollars, and values reported as inflation are adjusted.

As this was a database study, it was exempt from the Institutional Review Board, and no identifiable patient data were used; hence, no patient consent was required.

Statistical Analysis

Statistical analysis was completed using analysis of variance for continuous variables (i.e., age) and chi-squared test for categorical variables (i.e., gender, race, and mortality). A Mann-Kendall trend analysis was completed to assess the trend rates over the study period. Data analysis and management were completed using the IBM SPSS software package (SPSS version 22.0, SPSS Inc., Chicago, IL). Statistical significance was set at a probability of $P < 0.05$. Values are presented as median values for LOS and total costs.

RESULTS

From 2001 to 2011, there were a total of 451,823 elective procedures for CLI performed of which 76% ($n = 344,712$) were open. Overall, costs to treat CLI increased by 63% from \$12,560 in 2001 to \$20,517 in 2011 ($P < 0.001$; Table I). Demographics including age, gender, and race along with insurance status did not impact the cost of CLI care, but a significant increase in the utilization of endovascular therapy from 13.5% to 27.3% and an increase in the number of comorbidities of inpatients accounted for a 6% annual increase in cost per year despite the significant decrease in LOS from 6 to 5 days (Table I). Endovascular interventions were 20% more expensive compared with open surgery for CLI over this time period (\$19,566 vs. \$16,337, $P < 0.001$). Figure 1 depicts the rising cost of endovascular therapy as compared with open intervention.

From 2001 to 2011, the rate of SSI remained fairly stagnant ranging between 1.1% and 1.9%. However, patients with an SSI had total care costs that were 83% greater than patients who did not develop an SSI after procedure (\$30,949 vs. \$16,939; $P < 0.001$), and this trend was noted even when procedures were broken down into endovascular (\$32,389 vs. \$19,498) and open