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Episode-Based Cost Reduction for Endovascular Aneurysm Repair

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Abstract

Objectives—Effective strategies to reduce costs associated with endovascular aneurysm repair (EVAR) remain elusive for many medical centers. In this study, targeted interventions to reduce inpatient EVAR costs were identified and implemented.

Methods—From June 2015 to February 2016, we analyzed the EVAR practice at a high volume academic medical center to identify, rank, and ultimately reduce procedure-related costs. In this analysis, per-patient direct costs to the hospital were compared before (September 2013–May 2015) and after (March 2016–January 2017) interventions were implemented. Improvement efforts concentrated on three categories that accounted for a majority of costs: implants, CT scans performed during the index hospitalization, and rooming costs.

Results—Costs were compared between 141 pre-(PRE) and 47 post-implementation (POST) EVAR procedures. Based on data obtained through the Society of Vascular Surgery EVAR Cost Demonstration Project, it was determined that implantable device costs were higher than those at peer institutions. New purchasing strategies were implemented, resulting in a 30.8% decrease in per-case device costs between the PRE and POST periods. Care pathways were modified to reduce utilization and costs for CT scans obtained during the index hospitalization. Compared to baseline, per-case imaging costs decreased by 92.9% (P<.001), including a 99.0% (P=.001) reduction in post-processing costs. Care pathways were also implemented to reduce pre-procedural rooming for patients travelling long distances the day prior to surgery; resulting in a 50% decrease in utilization rate (35.4% PRE to 17.0% POST, P=.021) without significantly impacting median post-procedural

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length of stay (PRE-2 days (IQR 1-11), POST - 2 days (1-7), P=.185). Medication costs also decreased by 38.2% (P<.001) as a hospital-wide effort.

Conclusion—Excessive costs associated with EVAR threaten the sustainability of these procedures in health care organizations. Targeted cost-reduction efforts can effectively reduce expenses without compromising quality or limiting patient access.

Introduction

In 2014, The Society of Vascular Surgery (SVS) Patient Safety Organization (PSO) embarked on a major initiative to address the value of endovascular aneurysm repair (EVAR).[1,2] This EVAR Cost Reduction Project integrated hospital billing data with clinical quality data at 18 Vascular Quality Initiative (VQI) hospitals to evaluate variation in both cost and quality data. This undertaking allowed participating hospitals to benchmark costs and identify potential areas of savings. The pilot project also reported that EVAR costs frequently exceeded Medicare reimbursements, confirming that for a majority of institutions EVAR is associated with negative operating margins[3,4], thus threatening the sustainability of these procedures for many health care organizations.

As a participating institution in this project, we recognized that our EVAR-associated costs were higher than those accrued at peer institutions nationwide. As a result, several steps were undertaken to reduce these costs, including identifying improvement opportunities and implementing institution-specific interventions to reduce spending while maintaining quality outcomes. This report outlines the processes undertaken to improve the value of EVAR as a result of this exercise.

Methods

This study examined EVAR-related expenses for adult patients ≥18 years of age hospitalized at a 613-bed academic medical center during two specific sequential time periods. Individuals were included in the study if they had an inpatient admission with *Medicare Severity-Diagnosis Related Group* (MS-DRG) code 237, 238, 268 or 269 and *International Classification of Diseases – 9th edition* (ICD-9) code 39.71 or 39.78 or *International Classification of Diseases – 10th edition* (ICD-10) code 04U03JZ, 04U04JZ, 04V03DZ, or 04V04DZ and a discharge physician in the Division of Vascular Surgery. A baseline analysis of per-patient direct costs to Stanford Health Care (SHC) was conducted using retrospective claims data from September 2013 to May 2015. From June 2015 to February 2016, we implemented improvement projects in the three categories that accounted for a majority of costs. Post-intervention (POST) direct costs were collected from March 2016 to January 2017 and compared to the baseline, pre-intervention (PRE) period.

The study was submitted to the Stanford University Institutional Review Board, which waived the requirement for informed consent based on type of data analyzed and method of acquisition, IRB-44109.

Data Sources

Hospital direct costs, demographic data, encounter diagnoses, and primary procedure attending were obtained from the hospital's financial database system, a decision support and cost accounting system that integrates billing and gain/loss data to calculate hospital costs on a per patient, per case, and per unit basis. Several studies have previously used similar strategies to estimate the costs of healthcare services at individual hospitals.[5–7] Hospital costs included the sum of actual direct costs (not billed charges) for all services including room accommodations, procedural room time, medications, medical and surgical supplies, lab and imaging, and other ancillary services. Emergency Department (ED) costs were included if an individual was admitted to the hospital via the ED. Length of stay (LOS) benchmark data was pulled from the Clinical Data Base Resource Manager application owned and managed by *Vizient Inc.*, a consortium of member academic medical centers that shares quality, operational, and cost information for the purposes of benchmarking and improvement. The LOS index is the observed LOS compared to the expected LOS, based on reason for hospitalization and patient comorbidities. Intra-operative and post-operative details, including complications, were queried using the institution's VQI database and MS-DRG billing codes.

Interventions

Vascular surgeons collaborated with the institutional High Value Care (HVC) Team to identify areas of cost reduction. The HVC team was comprised of a financial analyst, staff members and physician administrator who worked on concurrent cost reduction projects across specialties. Vascular surgeons invested 2–3 hours/month on this project during the assessment and planning phases. In the pre-intervention cohort, the major components of cost were medical and surgical supplies including implant costs (52.6%), bed costs (14.7%), OR-related costs (14.6%), and imaging (7.3%), (Figure 1). The HVC team developed interventions that were concentrated on the top three drivers of inpatient costs under the surgeon's control: device costs, pre-procedural admissions, and inpatient radiology volume.

Quality Department improvement specialists designed Plan-Do-Study-Act improvement cycles to analyze baseline utilization, determine current-state and ideal-state frontline provider workflows, execute on improved workflows, collect data on performance, and adjust workflows as needed. Vascular surgeons met with HVC Team representatives monthly to plan interventions and review results. Ongoing hospital projects including pharmacy cost reduction were being implemented in parallel with the vascular surgery division efforts. This included using generic pharmaceuticals where possible and transitioning to lower cost intravenous drugs used during anesthesia and the post-operative period.

Intervention 1 – Device costs

Based on data obtained through the SVS PSO EVAR Cost Demonstration Project, it was determined that implantable device costs were higher than those at peer institutions. Working with hospital purchasing staff and an external consulting company, new purchasing strategies were implemented, including rebates for high-volume utilization and capped costs for complex cases. The consulting company had national pricing data to leverage negotiations for lower device costs with vendors.

Intervention 2 – Pre-procedural admissions

Given the geographic range of our practice in Northern and Central California, many patients travel significant distances for elective and urgent AAA care. In prior practice, patients travelling long distances the day prior to surgery were often admitted for a 23-hour pre-procedure stay to ensure readiness for surgery the following morning. This analysis determined that costs accrued during this pre-procedure admission were frequently not reimbursed. Clinical criteria allowing reimbursement for pre-procedural admission were developed, including need for pre-hydration in patients with chronic renal insufficiency.

Hospital LOS after EVAR was not identified as a significant intervention as our LOS index compared favorably to regional benchmarks. In calendar year 2014, our LOS observed to expected index, compared to other academic medical centers in California, was 0.74 for patients with standard grafts and 0.54 for patients with fenestrated or branching grafts. These patterns persisted in the first half of 2015 (Supplemental Table I).

Intervention 3 – Inpatient radiology costs

In prior practice, CT scans were frequently obtained during the index hospitalization to maximize patient compliance with the need for baseline post-operative imaging. As a result of the implemented cost saving strategies, inpatient CT scans after EVAR were not performed unless medically indicated. Instead, the use of more frequent telephone follow-up with patients and, when appropriate, having the initial post-procedural CT scan performed closer to the patient's home as an outpatient. When examined more closely, the balance of imaging expenses were related to post-processing costs following 3D image reformatting. As part of an evidence-based standardized care path, we developed clinical criteria to determine patients who required post-processing 3D reconstruction for images acquired during the index hospitalization. We worked with the Radiology Department to discontinue protocoled post-processing 3D reconstruction of abdominal/pelvic post-EVAR computed tomographic imaging studies without a specific surgeon-generated request. We also worked with our Information Technology Department to generate electronic health record order sets that allowed for elective authorization of post-processing 3D reconstruction, and educated all trainees, nurse practitioners, and faculty on this new process.

Study Variables

We examined patient and hospitalization characteristics, including admission source, admitting service, services utilized during admission, direct costs of services utilized, LOS, and case-mix index (CMI).[8] Patient medical records were queried to determine elective versus non-elective EVAR, the latter group defined as symptomatic or ruptured abdominal aortic aneurysms (AAA). We categorized EVAR procedures as either standard infrarenal repair or complex, the latter defined as procedures requiring fenestrated or parallel graft strategies for management of the proximal neck, or ancillary procedures to preserve internal iliac perfusion. Complications incurred during the index hospitalization, including re-interventions, were investigated using the institution's VQI database.[2] The faculty roster of surgeons involved did not change between the PRE and POST periods.

Data Analysis

The primary outcome of interest was the direct costs of services utilized. Univariable logistic regression was first applied to determine potential associations between study variables and the primary outcome of interest. Standard descriptive statistics were used to compare cases in the PRE and POST period. Chi-square tests were used to compare categorical variables. Student's t-test was used to compare normally distributed continuous variables, and the Wilcoxon rank-sum test was used to compare non-parametric data. Stata 14.2 was used to perform all statistical analyses (StataCorp LC, College Station, TX). A value of $P < .05$ was considered significant for all analyses.

Results

Our cohort comprised 141 PRE and 47 POST patients. Table I shows patient characteristics between cohorts. Age, sex, urgency of the surgery, and insurance type were similar between cohorts. CMI was significantly higher in the POST cohort (P<.001), with the percentage of complex cases increasing from 36.9% to 44.7%. Overall, average per-patient inpatient direct costs for cases with complex repairs were 35.8% (P<.001) higher than standard EVAR procedures.

Targeted cost reduction efforts led to significant savings. Restructuring of EVAR device contracts resulted in a 30.8% decrease in per-case device costs between the PRE and POST periods (intervention 1). By implementing standardized clinical criteria for pre-procedural "short stay" admissions, utilization decreased by 50% (35.4% PRE to 17.0% POST, P=.021) without significantly impacting operative readiness or the average post-procedural length of stay (PRE-3.0±2.5 days, POST-2.6±2.5 days, P=.185). This led to a 35.2% reduction in direct room costs (P=.101) (intervention 2). Compared to baseline, per-case imaging costs decreased by 93.3% (P<.001), including a 99.1% (P=.001) reduction in post-processing costs (intervention 3). A by-product of hospital wide care path implementation was a 38.3% reduction (P<.001) in costs related to inpatient medication usage for EVAR patients (Table II).

Analysis of intra-operative procedural variables demonstrated no statistically significant difference between procedure time, estimated blood loss, iodinated contrast use, and need for, or number, of units of blood transfused (See Table III). Complications were noted in 12.8% of patients in the PRE-period vs. 17.0% of patients in the POST period (P=.466) with no statistically significant difference between the type of complications incurred in either period (Table III). The length of stay, ICU admission requirements, and likelihood of discharge home following the procedure was similar between the two periods (Table III). The hospital length of stay was shorter for elective (2.6±0.6 days) versus non-elective procedures (5.4 ± 4.0 days, P<.001). The hospital length of stay was also shorter for standard procedures (2.3 ± 2.5 days) compared to complex procedures (3.4±2.6 days, P=.037).

Discussion

As EVAR has become the referent method of AAA repair in the United States[9–10], procedural costs have come under increasing scrutiny[11] The SVS PSO EVAR Cost Demonstration Project reported that mean inpatient costs of EVAR varied two to three-fold across several high volume centers.[2] Medicare reimbursement covered accrued costs for standard EVAR at only 6 of 18 (33%) participating centers; for complex EVAR, only 4 of 18 (22%). For many health care organizations, these unsustainable costs highlight the opportunity provided by the EVAR Cost Demonstration Project and future similar SVS PSO initiatives.[2]

This experience confirms that substantial EVAR-related savings are attainable through focused cost reduction efforts. To our knowledge, this is the first reported implementation of cost reduction strategies identified through SVS PSO Cost Demonstration Projects. Targeted areas of process improvement resulted in a 30.8% per case reduction in device costs, decreases in inpatient radiology imaging costs and pre-procedural rooming costs. This report adds to a growing literature of interventions identified to improve the value and sustainability of EVAR nationwide.[12,13] Although current VQI membership does not provide procedural cost and reimbursement analyses across participating centers outside of the Cost Demonstration Project framework, benchmarking of clinical outcomes allows for identification of improvement opportunities across all sites.

Since its inception, graft costs have been the main determinant of hospital expenses related to EVAR.[14,15] Unfortunately, graft costs continue to increase despite an ever-expanding marketplace of approved devices. Price transparency can reduce costs, as reflected by the SVS PSO EVAR Cost Demonstration Project, by providing price benchmarking to guide negotiations with vendors. To balance endografts development costs with sustainability considerations, transparency and open dialogue will remain essential in the years going forward.

When comparing standard versus complex EVAR, not surprisingly, complex procedures were substantially more expensive. Previous studies have clearly linked anatomic complexity with EVAR costs.[16–18] Fenestrated or branched EVAR procedures entail greater risks for serious complications and attendant hospital costs.[19–20] More research is needed to define cost-effectiveness as a function of procedural complexity, particularly for high-volume centers for whom these patients are usually referred.

Imaging accounted for a significant fraction of total procedural costs at our institution. As incident reimbursement for each hospitalization are capped within a single DRG designation, post-procedural imaging may significantly impact finances when obtained during the index hospitalization. In our practice, in general, once the initial post-operative CT scan identifies an optimal procedural result (good graft position, no type I A/B endoleaks, normal distal perfusion, etc.), follow-up surveillance is primarily ultrasound-based, with further CT scans reserved for patients with enlarging AAAs or otherwise problematic clinical conditions that limit the utility of ultrasound (e.g. excessive body mass index). As post-operative imaging may be financially beneficial for institutions[13], these

revenue opportunities need to be weighed against the overall societal costs for post-operative surveillance.[21,22]

We were able to decrease pre-procedural hospitalization by narrowing criteria for short stay admissions and organizing practical alternative options for eligible patients. These changes did not negatively impact our overall post-procedure hospital LOS. Current trials are examining the feasibility and safety of same-day EVAR[23,24], although existing Medicare reimbursement policies do not incentivize hospitals to discharge EVAR patients < 24 hours following the procedure. As the trend towards outpatient endovascular intervention continues to accelerate, reconsideration of the appropriateness of <24 hour stays following EVAR will be inevitable.

This study has several limitations warranting further consideration. The results obtained at a single academic medical center, may not be generalizable to other health care organizations across the United States. Hospitals with smaller procedural volumes may have less ability to negotiate substantial discounts with vendors. Additionally, direct costs and financial consequences were not accounted for beyond the index hospitalization. Outcomes were reported as percentage improvements (rather than specific dollar amounts) to avoid adverse influences on reimbursements provided by local insurers for services rendered, which if incurred would hamper further cost reduction efforts at our institution. Finally, our analyses were derived from hospital administrative claims data rather than direct cost accounting, and institutional variability in these methods may limit the generalizability of these results.

From planning to implementation, this project required seven months of dedicated time and coordinated effort from multiple administrative units of a large health care organization. Participation in the SVS PSO EVAR Cost Demonstration Project identified the opportunity, and enthusiastic participation by the vascular surgeons enabled rapid adoption and change. Informing physicians of the elements of procedural expense, and engaging their participation in cost reduction opportunities, are both important steps in improving the value of vascular disease care[25,26] as well as the sustainability of the American health care system overall.[27,28]

Conclusions

Excessive EVAR-associated costs threaten the viability of this AAA management method in many healthcare organizations. We leveraged institutional resources to significantly reduce EVAR-related expenses without compromising quality outcomes or patient access. Beyond EVAR, similar value-improvement opportunities exist for many other vascular-related interventions, and future SVS PSO efforts should be directed towards identifying and reducing excessive costs associated with procedural management of all aspects of vascular disease.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Two Sentence Summary

Collaborative efforts between vascular surgeons and hospital management led to cost reduction in graft costs, inpatient imaging utilization, and pre-procedural rooming costs. Similar efforts may yield substantial savings at other institutions.

Take Home Message

Based on the Society for Vascular Surgery EVAR Cost Demonstration Project, a collaborative program between vascular surgeons and hospital administrators reduced per-case device costs by 31% and per case imaging costs by 93%. Care pathways also reduced procedural rooming for patients travelling long distances, without significantly impacting length of stay. Medication costs also decreased by 38%.

Recommendation

The authors recommend a collaborative effort between vascular surgeons and hospital management to reduce costs of endografts, inpatient imaging, and pre-procedural rooming costs.

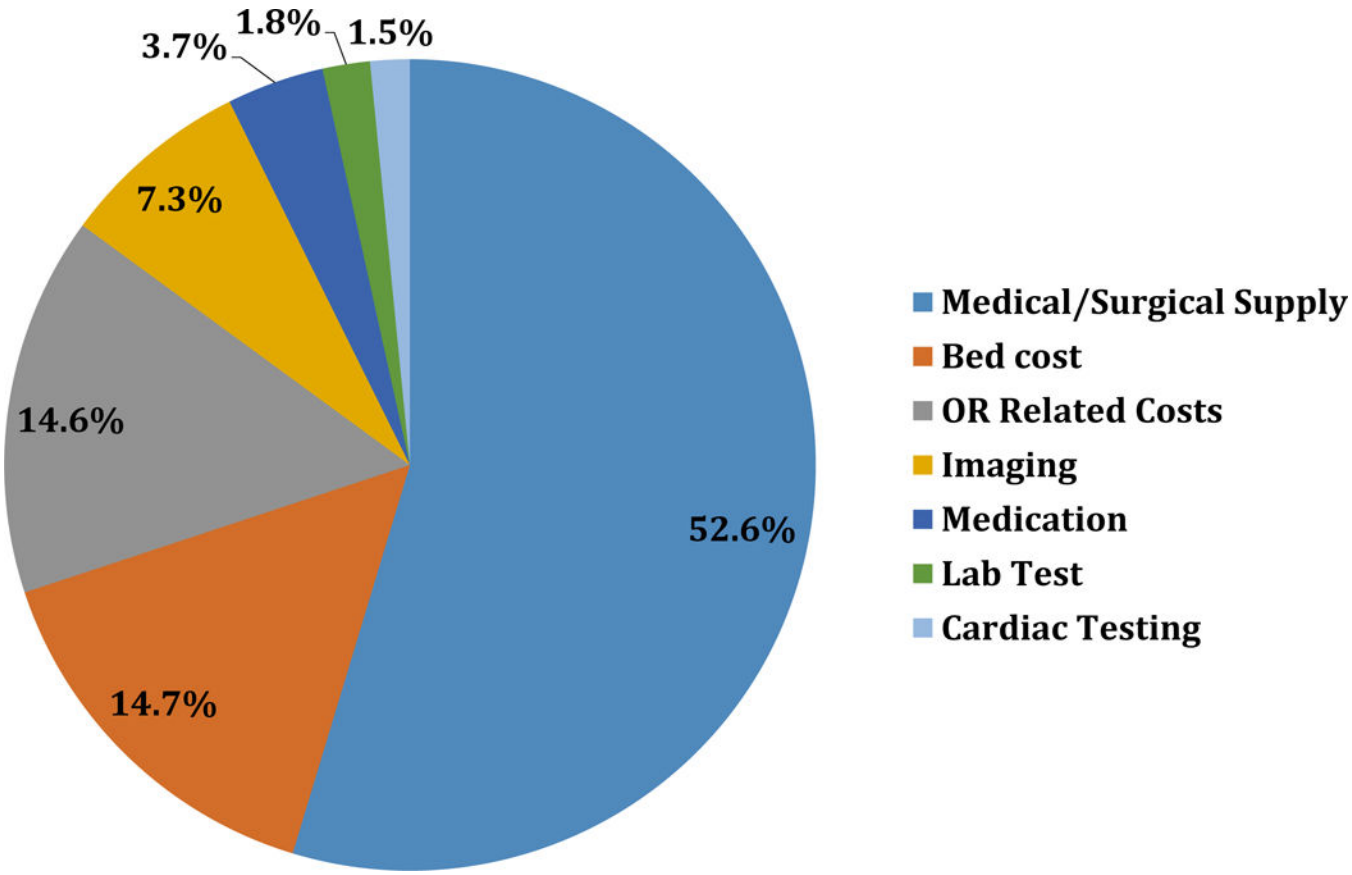

Figure 1.
Direct Cost Distribution (%) in PRE-intervention period

Table 1

Patient characteristics PRE- and POST-intervention

		Pre implementation (n=141)	Post implementation (n=47)	P-value*
Age		73.3±9.4	74.9±8.9	0.25
Male		80.7%	90.7%	0.14
Elective Case		82.1%	89.4%	0.25
Case Mix Index		3.60±0.57	4.32±0.90	<**0.001**
Procedure Type	Standard	63.1%	55.3%	0.34
	Complex	36.9%	44.7%	–
Commercial payor		13.5%	17.0%	0.55

*Based on Student's t test (parametric), chi-square test (categorical variables) or Mann-Whitney test (non-parametric). Parametric data are reported as mean± standard deviation

Table 2

Reduction in hospital direct costs due to interventions (PRE-POST/PRE)

Index direct cost during admission	Cost Reduction (%)	p-value
All Imaging	93.3%	<**.001**
Post-processing 3D reconstruction (Abdominal/Pelvis CT Angiogram)	99.1%	**.001**
Pre-procedural rooming	35.2%	.10
Rx and IV Therapy (Pharmacy)	38.3%	<**.001**

Table 3

Intra-operative and Post-operative Details

	Pre implementation (n=141)	Post implementation (n=47)	P-value*
Intra-operative Details			
Total Procedure Time (min)	147.9 ± 75.6	160.8±78.2	.32
Iodinated Contrast (cc)	68.6±36.7	79.3±29.9	.07
EBL (cc)	394 ±984	260±276	.36
pRBC transfusion	0.6±2.5	0.3±0.9	.42
Complications			
Identified by billing*	18 (12.8%)	8 (17.0%)	.47
Bowel Ischemia	1 (0.71%)	1 (2.1%)	.44
Leg Embolism	0 (0%)	1 (2.1%)	.25
Renal Complication	1 (0.71%)	2 (4.3%)	.16
Dysrhythmia	4 (2.8%)	3 (6.4%)	.37
Post-op MI	3 (2.1%)	3 (6.4%)	.17
Respiratory complication	1 (0.7%)	0 (0%)	1.00
Return to OR	3 (2.1%)	2 (4.3%)	.60
Surgical Site Infection	2 (1.4%)	0 (0%)	1.00
Post-operative Details			
Length of Stay (days)	3.0±2.5	2.6±2.5	.43
Median Length of Stay (IQR)	2 (1-11)	2 (1-7)	.19
Procedures requiring ICU stay	20 (14.2%)	6 (12.8%)	.81
Discharge Home	112 (79.4%)	36 (76.6%)	.63
Discharge Mortality	2 (1.4%)	2 (4.3%)	.27

*Identified by MS-DRG (237 vs. 238 pre-implementation, 268 vs. 269 post-implementation) - data source Vizient