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Reduced length of stay and 30-day readmission rate on an inpatient vascular surgery service

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As the cost of care for patients with specific diagnoses becomes fixed, hospitals must develop systems to reduce length of stay and optimize the use of hospital resources while maintaining a high quality of care. The goal of this study is to evaluate the implementation and efficacy of a system designed to reduce average length of stay on a vascular surgery service. To effectively reduce the average length of stay in our center, we restructured patient rounds, implemented multidisciplinary rounds, introduced clinical pathways to postoperative care, and expanded outpatient management of postoperative patients. A total of 1697 adult vascular surgery patients discharged while under the medical direction of a vascular surgeon between July 1, 2013, and June 30, 2016, were included in the study. Improving communication with critical staff and using procedural space outside of the main operating rooms led to a 2.8-day reduction in the length of stay (10.8 vs 8.0, P *< .001). There was a trend toward a reduction in the 30-day readmission rate (12% vs 10%, respectively;* P *= .01) and no significant difference in the case-mix index as a measure of illness severity (2.5 vs 2.4, respectively;* P *= .15). Length of stay reductions were heterogeneous among the types of vascular diseases studied, with greater improvements seen in patients undergoing lower extremity amputation, lower extremity angiogram, and endovascular aneurysm repair for non-ruptured abdominal aortic aneurysms. Less pronounced differences were observed in patients undergoing carotid artery endarterectomy or stenting and lower extremity bypasses. In conclusion, restructuring team rounds and instituting a multidisciplinary approach to discharge planning produced significant reductions in length of stay without a deleterious effect on patient care which may impact hospital profitability.* (J Vasc Nurs 2018;37:78-85)

Hospitals across the United States have suffered financial difficulties, with over 50% reporting financial losses during the recession of 2008–2009, placing the ballooning cost of health care under increasing scrutiny.[1] Profits are further complicated by a national shift from pay per admission to pay for performance. In 1971, Maryland implemented a system for hospital reimbursement. Established by the state law, the Maryland Health Services Cost Review Commission (MHSCRC) is an independent agency that sets reimbursement rates for all patients. Under this model, third-party payers are charged the same rate for the same care. The rates at individual hospitals are adjusted to account for each hospital's wages, charity care, severity of patient illness, volume, proportion of Maryland residents seeking care at the institution, and known rate of uncompensated care. In 2012, changes were made to incentivize quality and efficiency, and a financial penalty for all-cause readmissions within 30 days of discharge was imposed.[2] The MHSCRC is recognized as an alternative method to implement performance-based healthcare reimbursement, and Maryland continues to function with this financial model on a waiver status from the Affordable Care Act. As the cost of caring for a patient with a specific diagnosis becomes fixed, hospitals are developing systems to reduce the average length of stay (ALOS). Tertiary and quaternary centers that provide complex and emergent surgical care are anticipated to have the greatest impact from these systems, making this an important area of improvement at our center.[3,4]

On surgical services, attempts to reduce the ALOS commonly focus on maximizing preoperative outpatient evaluation, introducing postoperative pathways, and educating healthcare providers on the importance of reducing the ALOS.[5] Our patient population comprises a large volume of patients who present with acute illness from other hospitals and require emergent surgery, obviating preadmission evaluation. Given this clinical

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setting, we believed that the ALOS on our vascular surgery service could be reduced through other changes in practice, which are described in this article.

METHODS

A hospital billing database including all admissions to the University of Maryland Medical Center (UMMC) was used to select adult vascular surgery patients discharged between July 1, 2013, and June 30, 2016, while under the medical direction of a vascular surgeon. Implementation of the Epic electronic medical record occurred in November 2015. Therefore, to ensure accurate reporting, post-Epic data begins with December 1, 2015 discharges. We identified 1723 patients who presented either electively or emergently with diagnoses of thoracic and abdominal aortic aneurysms (AAA), carotid artery disease, critical limb ischemia, visceral artery aneurysm, and mesenteric ischemia, among others. Twenty-six patients with a length of stay of 0 days were excluded. This study was approved by the Institutional Review Board at UMMC.

Intervention

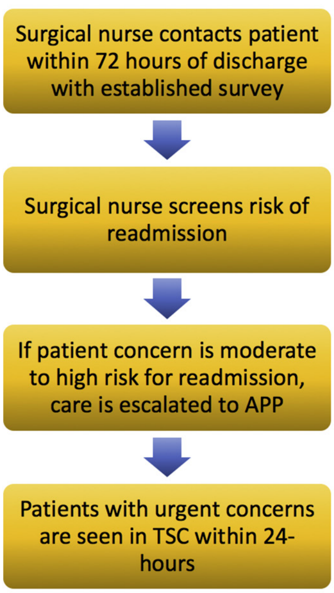
UMMC is a 757-bed tertiary care center in Baltimore, Maryland. The Division of Vascular Surgery comprises twelve faculty attending surgeons, six rotating fellows, and two advanced practice providers (APPs). General Surgery residents rotate on the service for 1- to 2-month blocks. Patients are primarily located on a medical-surgical telemetry unit with trained vascular nurses and a multidisciplinary team of a case manager, social worker, and allied health professionals. The interventions targeted improving communication between team members, introducing clinical pathways to postoperative care, optimizing the use of existing hospital resources, and expanding postoperative outpatient management.

To improve communication, the surgical and multidisciplinary patient rounds were restructured. At 6 AM daily, a vascular surgery attending, and APP met for rounds. Patients' daily plans were developed, and tasks were assigned for team members to execute. Multidisciplinary rounds (MDRs) with the APP, charge nurse, bedside nurses, case managers, social workers, and allied health professionals were restructured to occur at 8:30 AM. The APP acted as the liaison to communicate surgical team assessments from fellow-led rounds, augment plans based on surgical and allied health-driven data, and to delineate clear expectations for patients' care, including diagnostic imaging, laboratory tests, surgical planning, and discharge preparation. On weekends, morning rounds included the charge nurse, and discharge needs were discussed with the on-call case manager as needed. Discharge planning was discussed with patients and their families frequently to manage their expectations and prepare for outpatient recovery.

Expanding the management capabilities of the dedicated vascular surgery patient care unit further streamlined postoperative care. The medical surgery unit at UMMC comprises 12 beds. Additional training was provided to the nurses to expand the patient population that could be cared for on the patient care unit. This included training in monitoring arterial lines, insulin infusions, and performing frequent neurovascular checks (up to every 2 hours). This streamlined patients' postoperative courses by directing patients to a unit with nursing staff trained in vascular medicine and surgery and invested in early initiation of discharge planning.

Clinical pathways are standardized, evidence-based, interdisciplinary care management plans that outline an appropriate sequence of clinical interventions, milestones, and expected outcomes for a comparable patient population. Clinical pathways aim to increase quality of care by promoting safety, elucidating expected postoperative patient progression, and reducing ALOS. Pathways were developed with a focus on multidisciplinary care and implemented to direct the inpatient hospital course.

Redistribution of existing resources enabled the hospital to meet the needs of the growing vascular division. The UMMC has a



Hello, this is a follow-up call from (Name), one of the nurses from the Vascular Surgery Clinic. I am calling to see how you are feeling after your discharge from the hospital.

Question:	Assessment (Yes/No/NA):	Intervention - Provide clarification or appointment with APP:
Do you have any questions about your discharge medications, wound care, or wound vac?		
Do you have any of the following?:		
Fever (T>100.4°C)		
Nausea or vomiting		
Decreased tolerance to activity		
Drainage from incision		
Warmth, redness, or swelling of incision		
Abdominal or back pain		
Uncontrolled or unrelieved pain		
Color or temperature change in feet, legs, or hands		
Numbness		
Bleeding from any part of body		
Dark or bloody stools		
Chest pain or shortness of breath		
Sudden swelling of legs		
Do you have a follow-up appointment?		
Any other questions or concerns?		

Figure 1. *Transitional surgery clinic (TSC) workflow. APP = advanced practice provider.*

TABLE 1

PATIENT PROCEDURE CATEGORIES

Diagnosis	*Patients (n)*	*ICD-9-CM codes*	*ICD-10-PCS codes*
Carotid artery disease	113	38.12, 39.7, 0.63	03[7,C,H],[H,J,K,L,M,N]-
Aortic surgery	311	39.71, 39.73, 38.44, 39.52, 38.45, 39.25	04[1,7,B,C,H,L,P,Q,R,S,U,V,W], [0,1,2,3,4,5,9,A,C,D]-, 0470[0,3,4]-, 04[L,R,U,V]0-, 02[U,V]W-
Ruptured aortic aneurysm	36	441.1, 441.3, 441.5, 441.6	I71.1, I71.3, I71.5, I71.8
Lower extremity amputation	112	84.11, 84.12, 84.13, 84.14, 84.15, 84.16, 84.17, 84.3	0Y67-, 0Y68-, 0Y6C-, 0Y6D-, 0Y6F-, 0Y6G-, 0Y6H-, 0Y6J-, 0Y6M-, 0Y6N-, 0Y6P-, 0Y6Q-, 0Y6R-, 0Y6S-, 0Y6T-, 0Y6U-, 0Y6V- 0Y6W-, 0Y6X-, 0Y6Y-
Lower extremity open surgery	151	33.14, 38.18, 38.08, 38.48, 38.68	The following procedures were separated by open versus percutaneous or percutaneous endoscopic
Angiogram	341	39.5, 39.79, 39.9, 0.4, 0.41, 0.43, 0.45, 0.46, 0.47, 0.48, 0.49, 0.55, 0.6, 38.7, 88.4/ 41/42/43/44/45/47/48/49/51, 99.1	04,[1,7,B,C,H,L,P,Q,R,S,U,V,W], [E,F,H,J,K,L,M,N,P,Q,R,S,T,U,Y]-, 031[5,6] 0[9,A,J,K,Z][6,7,8,9,B,C], 02C[Q,R,]- B31[0,1,2,3,4,5,6,7,8,6,B, C,D,F,G,H,J,K,L,N,P,Q,S,T,U]-, B41 [0,2,3,4,5,6,7,8,9,B,C,D,F,G,J]-, 3E0[4,6] [0,3]17

ICD-9-CM = International Classification of Diseases, Ninth Revisions, Clinical Modification.

dedicated endovascular catheterization laboratory that had been primarily devoted to cardiac procedures. The catheterization laboratory nursing and ancillary staff were trained and supplied with the equipment necessary to accommodate other endovascular procedures, including diagnostic and therapeutic angiogram, thrombolysis, and inferior vena cava filter placement. These procedures, once limited to the main operating rooms, were redirected to the catheterization laboratory, decreasing the load on the main operating rooms and increasing the availability of operating room time for complex endovascular and open surgical procedures.

In planning for reducing ALOS, we recognized there would be an abbreviated time for patients and their families to become proficient in self-care and for the surgical team to monitor for postoperative complications such as wound infection. Therefore, a multidisciplinary team of outpatient nurses and APP developed a multifaceted approach to address common issues that arise shortly after discharge. All patients discharged to home received a standardized telephone questionnaire within 72 hours. This survey was modified from previously published tools[6–8] to identify problems that may lead to readmission, including questions regarding wound healing, signs or symptoms of infection, and general well-being (Figure 1). If a patient provided a response that raised concern for a postdischarge complication or readmission, a provider would determine if further intervention was warranted in an APP-led clinic. An underutilized clinical space within the hospital was repurposed to accommodate these visits without overloading the surgeons' outpatient clinical space. Patients could be scheduled for a same-day visit to obtain labs and diagnostic imaging, evaluate wound care, and coordinate home health services.

Procedural analysis

After excluding patients with a length of stay of zero days and greater than 21 days, we grouped patients based on the International Classification of Diseases, Ninth Revisions, Clinical Modification (ICD-9-CM) and the ICD-10-PCS codes. The codes were grouped into 5 categories (carotid artery disease, aortic surgery, amputations, lower extremity open surgery, and angiogram, with aortic aneurysms differentiated as ruptured or nonruptured; Table 1). Patients undergoing both lower extremity amputation and bypass were only included in the open lower extremity group. Patients undergoing aortic surgery in addition to another operation were only included in the aortic surgery group. Patients in the angiography group did not have other operations performed during the operation of record considered. A total of 1,064 patients were included.

Economic analysis

We obtained financial data for each patient's inpatient hospital course (direct variable expense, direct fixed expense, total cost of hospitalization). Indirect expenses, which include overhead costs incurred in maintaining infrastructure (e.g., administrative costs) and environment (e.g., electricity, water, maintenance, rent), were excluded as they are distributed across all departments and are not necessarily billed in proportion to a patient's use of services. Furthermore, these costs are fixed and are not likely to vary by the volume of vascular cases performed or the complexity of any single case, making them less valuable contributors to the overall assessment of profitability of a particular admission. Direct variable expenses are costs that directly pertain to the provision of patient care and vary with patient volume. These include salaries for nurses, technicians, allied health professionals, and other staff; prosthetic implants; pharmaceuticals; operating room costs; laboratory tests; and radiology, making them dependent on ALOS and the operative intervention provided. Direct fixed expenses pertain to the provision of patient care and do not vary in relation to patient volume. Finally, costs accrued in the outpatient setting or in subsequent hospitalizations were not included in this analysis.

Statistical analysis

Means and standard error of the mean were calculated and compared. Continuous variables were compared using two-tailed Student's *t*-test for normally distributed variables. Chi-squared test was used to compare readmission rates. Data are reported as mean ± standard error of the mean. Statistical significance was determined at a P value < .05. Statistical analyses and figure generation were performed using GraphPad Prism 5 (GraphPad Software, San Diego, CA).

RESULTS

A total of 1723 patients were identified in our search, of which 1697 were included in our analysis (631 before intervention, July 1, 2013, to June 30, 2014; 1066 after intervention, July 1, 2014, to June 30, 2016). There was no difference in patient volume between the two groups as measured by the number of discharges per month (54 ± 8 vs 47 ± 7, P = .19). Case-mix index (CMI) is a reflection of the acuity of the patient population reported during a specific time frame. There was no difference in CMI between the study groups (2.5 ± 0.07 vs 2.37 ± 0.05, P = .151; Figure 2). The ALOS for the studied population decreased significantly with implementation of the aforementioned interventions (10.8 ± 0.5 vs 8.0 ± 0.2 days, P < .001; Figure 2). This reduction remained significant when adjusted for CMI (4.7 ± 0.2 vs 3.8 ± 0.1 days, P < .001; Table 2). During the study period, 187 patients were readmitted in less than or equal to 30 days, with a trend toward reduction in this measurement after the intervention (81 before intervention vs 106 after intervention, P = .010; Table 2).

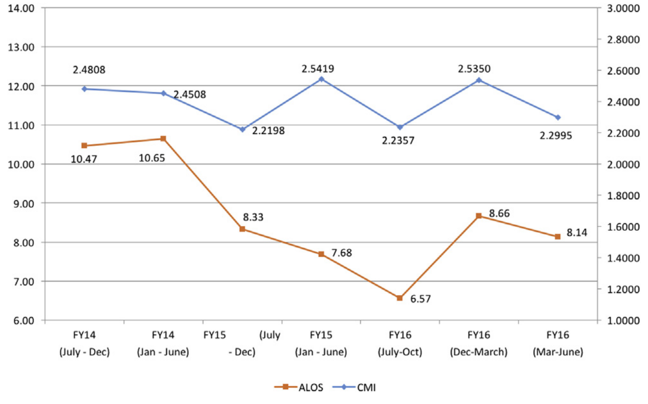


Figure 2. *Vascular surgery average length of stay (ALOS), measured in days, and case-mix index (CMI) are based on inpatients discharged within the time frame as laid out and inpatients with a vascular surgeon as their physician of record at the time of discharge. CMI is a reflection of the acuity of the patient population reported during a specific time frame.*

The reduction in length of stay was not equally distributed between the surgical procedures reviewed. Patients undergoing carotid artery stenting, carotid endarterectomy, lower extremity amputations, angiography, endovascular repair of abdominal aortic aneurysm (EVAR) for nonruptured AAA, or aorta-iliac-femoral bypass all experienced significant reductions in length of stay. Those undergoing open lower extremity operations such as bypass or endarterectomy, thoracic endovascular aortic repair (TEVAR), or aortic surgery for a ruptured aneurysm did not experience a reduction in length of stay (Table 3).

The mean cost of inpatient care before the intervention was $32,896 ± 1,413 per patient, which was not significantly different after the intervention (P = .70; Table 2). The mean direct variable expense before the intervention was $23,801 ± 1,059 per patient, which did not differ after our intervention (P = .81), and the mean direct fixed expense was $9,095 ± 373 per patient, which did not change (P = .43).

DISCUSSION

This study found that implementing MDR, APP management of inpatients, postsurgical pathways, transitional surgery clinic, and using procedural space outside of the main operating rooms significantly decreased our ALOS, but was not associated with a financial benefit. However, causation with any intervention independent of others cannot be determined. As we have previously proposed, in medical centers, such as ours, with a high preponderance of nonelective vascular surgery, specific management, training, and resource capabilities may further reduce ALOS and increase hospital profitability.[9] To our knowledge, no similar group of interventions has been documented in a similar vascular surgery population.

MDR is emerging as a tool to improve team communication, patient outcomes, and ALOS. This is well documented on trauma services where social and patient placement needs frequently delayed discharges[10,11] and more recently in vascular surgery.[12] Others have assessed the impact of twice daily attending rounds and 24-hour chief resident availability to nursing, showing an improved sense of safety and team approachability without a difference in inpatient mortality, cardiac arrest, reoperation, or readmission.[13] APP-led rounds have emerged as another means to decrease ALOS and improve nurse and physician satisfaction.[14] Our experience is that APPs are essential to the safe, efficient care of surgical inpatients and provide a continuity of care that is difficult to achieve with residents frequently changing services and having responsibilities in locations other than the patient care unit.

Clinical pathways are widely used in medicine to improve outcomes, decrease costs, and improve ALOS and have been reported in the vascular literature as far back as 1997.[15,16] Postoperative pathways were implemented at our institution to improve team efficiency. Key to the success of these tools is the support of

TABLE 2

LENGTH OF STAY ANALYSIS

	Control (n = 631)	*Intervention (n = 1066)*	**P** *value*
Patient volume, no. of discharges/month	54 ± 8	47 ± 7	.19
Case-mix index, mean ± SEM	2.5 ± 0.07	2.37 ± 0.05	.15
Length of stay, mean ± SEM, days	10.8 ± 0.5	8.0 ± 0.2	**<.001**
Case-mix index adjusted length of stay, mean ± SEM, days	4.7 ± 0.2	3.8 ± 0.1	**<.001**
30-day Readmission, no., %	81, 12	106, 10	.01
Cost of inpatient care (direct variable + direct fixed costs), USD	32,896 ± 1,413	31,974 ± 1,020	.59
Direct fixed expense, USD	9,095 ± 373	8,674 ± 260	.34
Direct variable expense, USD	23,801 ± 1,059	23,300 ± 784	.7

SEM = standard error of the mean; USD = US dollars ($).
The bold for <.001 is to highlight the significance.

APP and nurses to promote adherence and recognize when deviation occurs. More recently, an urban tertiary care hospital published a comparison of acute aortic disease patient outcomes before and after implementation of clinical pathways, noting improved outcomes, decreased mortality, and decreased time to intervention.[17] Our experience was that some diagnostic groups had more predictable recovery, and patients were less likely to deviate from the clinical pathway; these included patients undergoing the following procedures: 1) carotid artery stent/endarterectomy, 2) lower extremity amputations, 3) angiography, 4) EVAR for nonruptured AAA, or 5) aorta-iliac-femoral bypass. Lower extremity bypass and endarterectomy, TEVAR, and aortic surgery for ruptured aneurysm were more likely to have patient-specific circumstances that influenced ALOS and less likely to follow a prescribed pathway of recovery.

Importantly, attempts to reduce ALOS must be balanced by interventions to ensure patients are not discharged only to be readmitted at a later date. As part of the MHSCRC, all-cause readmissions to any Maryland hospital are centrally tracked and reported. Therefore, readmission penalties include not only those patients who are admitted back to the original facility but additionally those admitted to other Maryland hospitals. A tertiary center is challenged with a broad geography of patients served. Discharge plans must adapt to accommodate the available resources in the county in which the patient resides and must address that patients may seek medical attention and guidance from other facilities if recovery expectations are not clear and early home interventions are not convenient. We believe readmissions were minimized through discharge planning coordinated by multiple team members early in each patient's hospitalization and through close follow-up in the form of telephone nurse assessment questionnaires to identify problems within 72 hours of discharge. This system addressed potential problems before a serious complication arose, identified complications early, and ensured patients had appropriate follow-up, laboratory work, and home health services. Patients who underwent vascular surgery are commonly discharged on new medications that are associated with increased rates of readmission (eg, anticoagulants, antiplatelet agents, antibiotics) and have high rates of wound complications that are commonly managed by negative pressure therapy or complex and frequent dressing changes.[18] An intervention that ensures patients are comfortable with their discharge care, do not have lingering questions, and can be seen if needed in a prompt fashion facilitated early discharge from the hospital.

One limitation of this study is that we did not attempt to quantify the effect of these interventions on the cost of outpatient care. Increased home health utilization and wound supplies likely impact both the ambulatory cost, to insurance providers, and out-of-pocket costs, to patients. Another intervention that was not included but could have further aided our efforts would be to ensure regularly scheduled follow-up appointments were made before patient discharge from the hospital. Unfortunately, we were unable to assess readmissions to other hospitals and were limited to readmissions to our hospital.

Our study period coincides with the introduction of the Critical Care Resuscitation Unit, a six-bed intensive care unit in the R Adams Cowley Shock Trauma Center with the goal of increasing adult critical care transfers to UMMC and improving outcomes. In the year after this unit opened, overall transfers increased 65%, and those of critically ill surgical patients increased by 94%.[19] Within our division, specifically, there was nearly a four-fold increase in the number of patients transferred to the vascular surgery service. The number of aortic operations performed at our hospital more than doubled (92 vs 219) and was distributed between EVAR, TEVAR, and open aortic aneurysm repair. The number of patients with the diagnosis of ruptured aortic aneurysm increased from 10 to 26. Increased critical care transfers and aortic operations infer a rise in the severity of illness treated. Despite this influx of patients with critical vascular issues, it is notable that there was no significant change in CMI during the study period. This has a significant impact on the cost as the MHSCRC uses CMI to rate-adjust reimbursements for specific diagnoses or reduce financial penalties associated with complications.

TABLE 3

AVERAGE LENGTH OF STAY FOR COMMONLY PERFORMED PROCEDURES

	Carotid disease		*Lower extremity open procedure*		*Lower extremity amputations*		*Angiogram*	
	Pre (n = 40)	*Post (n = 86)*	*Pre (n = 39)*	*Post (n = 112)*	*Pre (n = 44)*	*Post (n = 68)*	*Pre (n = 128)*	*Post (n = 185)*
Age (y)	67.0 (1.5)	66.7 (1.1)	66.7 (2.3)	61.3 (1.4)*	57.6 (1.9)	62.7 (1.7)*	59.9 (1.3)	59.0 (1.0)
CMI	1.58 (0.11)	1.35 (0.05)	3.02 (0.20)	2.68 (0.09)*	2.57 (0.16)	2.19 (0.14)*	2.10 (0.10)	2.11 (0.08)
ALOS (d)	3.9 (0.6)	2.6 (0.3)**	8.5 (0.8)	7.8 (0.4)	11.2 (0.7)	8.1 (0.5)**	8.1 (0.4)	5.9 (0.3)**
CMI-adjusted ALOS (d)	2.5 (0.3)	1.9 (0.2)*	3.0 (0.3)	3.0 (0.2)	4.62 (0.25)	4.12 (0.24)	4.6 (0.3)	3.4 (0.2)**
Direct variable cost (USD)	8,587 (675)	9,953 (550)	20,928 (1,957)	23,807 (1,430)	16,164 (1,415)	14,153 (981)	19,220 (982)	17,409 (796)
Total cost (USD)	21,243 (1,503)	22,772 (1,236)	42,378 (3,701)	47,353 (2,496)	34,365 (2,806)	30,081 (1,971)	36,451 (1,811)	32,653 (1,334)*

	All aortic surgery		*EVAR, nonruptured*		*TEVAR, nonruptured*		*Aortoiliac occlusive disease*	
	Pre (n = 92)	*Post (n = 219)*	*Pre (n = 20)*	*Post (n = 59)*	*Pre (n = 17)*	*Post (n = 57)*	*Pre (n = 11)*	*Post (n = 26)*
Age (y)	66.8 (1.4)	67.6 (0.9)	73.5 (1.6)	72.5 (1.5)	65.6 (2.6)	67.7 (1.8)	52.3 (4.2)	60.7 (2.2)*
CMI	3.36 (0.17)	3.11 (0.09)	3.02 (0.39)	2.39 (0.09)**	3.39 (0.31)	3.06 (0.12)	3.15 (0.37)	3.47 (0.28)
ALOS (d)	9.4 (0.5)	7.7 (0.3)**	7.1 (1.0)	4.8 (0.6)**	9.1 (4.4)	8.2 (0.5)	12.3 (1.1)	9.1 (0.8)**
CMI-adjusted ALOS (d)	3.14 (0.22)	2.61 (0.11)**	2.69 (0.38)	1.96 (0.21)**	2.79 (0.24)	2.76 (0.18)	4.23 (0.45)	2.87 (0.28)**
Direct variable cost (USD)	36,806 (2,120)	36,072 (1,490)	38,954 (3,267)	34,670 (2,605)	47,176 (6,395)	50,561 (3,150)	25,651 (3,723)	23,950 (1,787)
Total cost (USD)	63,389 (3,169)	62,580 (2,293)	62,335 (5,576)	51,222 (3,683)*	76,804 (9,156)	82,882 (4,850)	53,585 (6,488)	49,105 (15,724)

ALOS = average length of stay; CMI = case-mix index; EVAR = endovascular repair of abdominal aortic aneurysm; TEVAR = thoracic endovascular aortic repair; USD = US dollars ($).
All data are reported as mean (standard error of the mean). *$P < .1$; **$P < .05$.

CMI was designed by the Centers for Medicare and Medicaid to calculate hospital payments as they relate to resource consumption. It is often used, as in this study, as a surrogate for illness severity. Therefore, CMI is higher for patients who use more resources, not necessarily patients with a more severe disease. Furthermore, CMI is highly dependent on provider documentation and coding accuracy and can be affected by the skill set of the coders or training providers and coders.[20–23] Of note, no project to improve the accuracy of coding was undertaken in the division of vascular surgery during this time. Future projects in our division may target accurately capturing comorbidities to improve coding.

Finally, despite a decrease in ALOS, there was no significant impact on the cost of inpatient stay, which others have similarly reported.[24] In analyses of cost of stay per day, for most patients, the costs that are directly attributable to the last day of a hospital stay are an economically insignificant component of the total cost of stay, suggesting there is a limit to savings that can be achieved with ALOS reductions. Patients need to spend a reasonable amount of time hospitalized, and with reductions in ALOS, costs and procedures that had been incurred at the end of a patient's stay are likely transferred to an earlier day in the hospitalization. It is only possible to reduce hospital expenditures when a reduced volume of inpatient days allow cost-saving measures to be performed, such as decreasing staffing levels by closing inpatient nursing units. These measures reduce overall fixed costs, resulting in measurable savings.

Associated with this, endovascular technologies broadened the options for treatment of many vascular lesions and have reduced ALOS compared with traditional interventions.[25–29] In addition to shortened ALOS, endovascular intervention is credited with decreased perioperative morbidity and hospital-acquired infections.[25,26] Despite these advantages, the necessary imaging, procedural, and supply costs of endovascular therapies far exceed the cost of a traditional open surgery.[27,28] Walker et al[29] proposed an alternative reimbursement model that stratifies vascular lesions using the TransAtlantic Intersociety Consensus II (TASC II) scoring system, imploring that the cost of treating lower extremity vascular disease be driven by the complexity of the lesion. This is not accounted for in a diagnosis-related group reimbursement model and may further complicate pay-for-performance reimbursement.

A strength of this study is that it is an analysis of a unique state-regulated all-payer hospital reimbursement system. This reduces variance inherent when individual contracts with hospitals and third-party payers determine payments levels, which is the case in many states. In those situations, reimbursements for Medicare are typically lower than those for commercial payers relative to the cost of treatment, forcing hospitals to implement "cost shifting" or increasing prices to private insurers. Furthermore, outside of this system, uninsured patients are usually charged high prices that no insurer would actually pay, making a hospital unable to collect payment. In a fixed reimbursement model, such as ours, hospitals must charge the same rate, regardless of insurance type or lack of insurance.

A limitation of our study is the use of direct costs for clinical services. This does not consider indirect costs. Our analysis is further limited to the acute inpatient period, excluding follow-up care and outpatient rehabilitation. Rehospitalization outside of our center is also unknown. The data examined were obtained from an administrative database, which hinders our ability to comment on patient entry point to the hospital and adverse events such as death or unplanned surgical intervention. Finally, we did not examine the overall revenue during the study period. Thus, the total cost to the health-care system is understated; however, our focus was on assessing ALOS and the associated financial implications during the acute period of care.

As a specialty, vascular surgery has evolved significantly in the past two decades. The advent of endovascular therapies changed the landscape of general vascular practice. These changes are similar to those experienced in general surgery with the arrival of laparoscopy. Both specialties have seen a segregation of specialists into those with primarily minimally invasive/outpatient practices and those with largely inpatient-based patient populations; the latter was generally based at large, tertiary care centers. In general surgery, this resulted in the birth of acute care surgery as a unique specialty. This work and others by our group[9,30] highlight that a team dedicated to caring for patients with acute vascular diseases that demand intense resource utilization can optimize outcomes, achieve efficiency, and contain costs. It is not unreasonable to think this model will continue to sprout at high-volume/high-acuity centers and evolve into its own academic practice and identity, mirroring what has occurred in general surgery.

CONCLUSIONS

Our findings support MDR, early discharge planning, and early identification of patients who will undergo procedures associated with significant lifestyle changes that complicate their discharge. This led to a 2.8-day reduction in ALOS and reduced 30-day readmission in an urban, tertiary teaching hospital. Reductions in ALOS were not equal across surgical procedures, suggesting the need for different strategies to improve the delivery of care in different patient populations. The key to success of these interventions is educating the individuals involved in patient care about expected care pathway, recognizing when patients are not advancing appropriately, initiating discharge planning early, and maintaining close follow-up after discharge. We seek to provide an outline that both large, tertiary centers and community-based hospitals can use to provide high-quality acute vascular surgical care with reduced variation in care, reduced length of stay, optimized outcomes, and minimized 30-day readmissions.

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