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A Cost and Outcome Analysis of Endovascular vs Open Repair of Blunt Traumatic Aortic Injuries

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Background: Aortic injury is the second most common cause of death after blunt trauma. Thoracic endovascular aortic repair (TEVAR) has been rapidly adopted as an alternative to the traditional open repair (OR) for treatment of traumatic aortic injury (TAI). This paradigm shift has improved the outcomes in these patients. The purpose of this study is to evaluate the inpatient cost and outcomes of TEVAR compared to OR for patients with TAI.

Methods: We analyzed prospectively collected data from the institutional trauma registry between April 2002 and June 2010. These data were supplemented with a retrospective review of hospital financial accounts. Primary outcomes were mortality and total hospital charges. Secondary outcomes included major complications, intensive care unit (ICU), preoperative, postoperative, and total hospital length of stay (LOS). Univariate analysis was performed for comparison of outcomes and cost. Logistic regression was used to compare the rates of complications. Wilcoxon rank sum test was used to compare the median cost of the treatments.

Results: One hundred and six (106) consecutive patients (74 male, mean age 36.4 years) underwent OR (n = 56) and TEVAR (n = 50) for treatment of TAI. Detailed data are shown in the Table. The proportion of patients who underwent TEVAR compared to OR increased from 0% to 100% during the study period. The TEVAR patients were significantly older than the OR patients. There was no significant difference in the injury severity score (ISS), mortality, stroke, paraplegia, total LOS, ICU LOS, or median hospital cost. The incidence of uninsured patients was similar in both groups. Due to a policy of delayed selective management, the preoperative LOS was significantly higher for TEVAR. The rate of complications was significantly higher for OR. For patients who underwent OR, the estimated relative risks (95% CI) of mortality and complications were 2.23 (0.45, 11.00), and 1.79 (1.23, 2.84), respectively. Our findings were not impacted when the comparisons were made adjusted for age.

Variable	*OR (N = 56)*	*TEVAR (N=50)*	P *value*
Male N (%)	39 (69.6)	35 (70.0)	1.00
Age mean (SD)	32.16 (14.23)	41.06 (20.32)	**.012**
ISS mean (SD)	37.96 (9.98)	36.68 (9.81)	.51
Mortality N (%)	5 (8.9)	2 (4.0)	.44
Stroke N (%)	0 (0.0)	1 (2.0)	.48
Paraplegia N (%)	0 (0.0)	0 (0.0)	1.00
Total LOS mean (SD)	33.49 (29.08)	27.74 (23.83)	.27
Pre-op LOS mean (SD)	2.77 (6.38)	11.14 (18.51)	**<.0001**
Post-op LOS mean (SD)	29.73 (28.56)	16.88 (13.61)	**.0035**
ICU LOS mean (SD)	19.80 (21.57)	16.94 (16.39)	.44
Complications N (%)	32 (57.14)	16 (32.00)	**.012**
Total charges median	$85,379	$86,431	.64
Un-insured N (%)	17(30.36)	14(28.00)	.68

Conclusions: Compared to OR, patients who underwent TEVAR, despite being older, had a significant reduction in complications. Although the observed mortality rate for OR was at least twice that of TEVAR (8.9% vs 4.0%), the difference was not found to be statistically significant. The median cost of TEVAR was not significantly different compared to OR.

Long-Term Secondary Procedures after Aneurysm Repair: Is EVAR Really Worse than Open Repair

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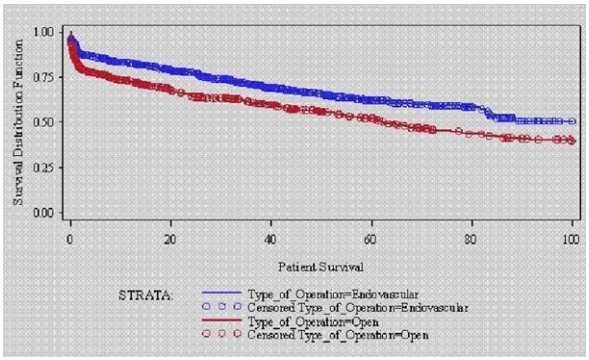
Background: Since the development of endovascular repair (EVAR) of abdominal aortic aneurysm (AAA), there remains concerns regarding its durability, need for secondary procedures, and associated long-term morbidity. We compared these two approaches to evaluate their respective long-term durability.

Methods: All patients who had undergone endovascular and open AAA repair were identified from a prospectively maintained registry. Health system charts, medical communication, and national death indices were reviewed. Secondary interventions were classified as vascular (aortic graft or remote) and nonvascular (incisional or gastrointestinal).

Results: Between July 1985 and August 2009, 1923 patients underwent 1990 AAA repair procedures (EVAR = 1064; Open = 926). Patients were followed up to 290 months (mean 27.6 ± 35.9) and identified with 420 surgical encounters (EVAR 224%-21.1%; Open 196%-21.2%). Most (323%-76.9%) encounters were related to vascular disease: 173 (EVAR = 128; Open = 45) were related to the aortic graft; 150 (EVAR = 96; Open = 54) were related to nonaortic vascular disease. The remaining 97 (23.1%) surgical encounters included incisional hernias, small bowel obstruction, intrabdominal abscesses, and wound dehiscence requiring operation. Of these 97 (EVAR - 0, Open - 97) encounters, 65 required surgical intervention, 14 required hospitalization, and 18 required outpatient only consultation. By survival analysis for a period of 100 months, all-cause mortality rate was 24.5% after EVAR and 38.8% after open repair. One-year survival was 83.6% (±1.22) and 72.4% (±1.76), while 5-year survival was 63.6% (±2.17) and 51.9% (±2.41) for EVAR and open repair, respectively (log-rank *P* value <.0001).

Conclusions: EVAR patients require more late secondary vascular interventions than open AAA repair, but patients who undergo open repair have more nonvascular long-term morbidity. Long-term survival is better after EVAR compared to open repair in this selected patient group.



National Utilization and Outcome of Carotid Artery Revascularization in Octogenarians

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Background: The benefits of carotid endarterectomy (CEA) and carotid artery angioplasty and stenting (CAS) in octogenarians remain unclear. Octogenarians were excluded from seminal CEA trials. CAS may have increased complications in this patient cohort. The objective of this study was to examine the national utilization and outcome of CEA and CAS in octogenarians.

Methods: The Nationwide Inpatient Sample (2004-2005) was utilized. ICD-9 codes were used to identify CEA and CAS cases. Outcomes included in-hospital stroke and death. Comparisons were performed between older and younger patients. Analysis was performed among octogenarians to identify whether improved outcomes were noted with either procedure.

Results: A total of 54,658 cases were analyzed; 10,826 were in octogenarians (19.8%). Octogenarians who underwent carotid procedures were more likely to be female (45.6% vs 41.5%, $P < .001$) and to die in the hospital (1.0% vs 0.6%, $P < .001$) than younger patients who underwent carotid procedures. There were no overall differences in the prevalence of preoperative symptoms (5.4% vs 5.3%), the use of CAS as opposed to CEA (6.0% vs 5.8%), or the overall rate of periprocedural stroke (1.1% vs 1.1%) between octogenarians and younger patients. However, asymptomatic oc-

togenarians were more likely to undergo CAS (as opposed to CEA) than asymptomatic younger patients (10.1% vs 5.7%, $P < .001$). In separate analysis of octogenarians alone, it was noted that they had a significantly higher rate of periprocedural stroke with CAS than with CEA (2.2% vs 1.1%, $P < .01$). The increased rate of stroke with CAS as opposed to CEA was noted in both asymptomatic (1.9% vs 0.9%, $P = .04$) and symptomatic (5.2% vs 2.3%, $P = .18$) octogenarians.

Conclusions: Nationally, octogenarians comprise nearly 20% of patients undergoing carotid revascularization procedures, despite concern regarding the benefits of these procedures in older patients, particularly when asymptomatic. In spite of additional specific concerns regarding the complication rate of CAS in patients older than 80 years of age, asymptomatic octogenarians underwent CAS as opposed to CEA significantly more frequently than younger patients. However, their periprocedural stroke rate overall was equally low when compared to younger patients. Furthermore, among octogenarians, the rate of periprocedural stroke was significantly higher with CAS than with CEA, and this remained a significant finding when asymptomatic cases were separately examined. CEA may be the treatment of choice for properly selected octogenarians, unless compelling reasons exist to perform CAS.

Renal Artery Stenting for Salvage of Renal Function: Preoperative Predictors of Outcome Guide Patient Selection

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Background: Improved renal function after renal artery bypass surgery has been associated with improved dialysis-free survival. Unfortunately, renal artery bypass in patients with ischemic nephropathy carries a 4% to 7% operative mortality rate. Renal artery stenting (RAS) offers a lower risk of mortality, but the clinical response rates for RAS have been disappointing. We surmise that the poor results for RAS are related to inadequate patient selection. The purpose of this study was to identify preoperative clinical features that predict a durable improvement in renal function with RAS.

Methods: The study cohort consisted of 43 patients with renal insufficiency (serum creatinine $\geq$ 1.5 mg/dL) who underwent RAS for renal salvage. Patients were categorized as "responders" if estimated glomerular filtration rate (eGFR) at last follow-up was improved 20% or more over baseline. Patients with stable or worse renal function after RAS were labeled "nonresponders." For the purpose of calculating changes in eGFR, patients on dialysis were represented by an eGFR of 10 mL/min/1.73 m^2. Renal volume was estimated as kidney length $\times$ width $\times$ depth/2.

Results: The median age of the cohort was 69 years (interquartile range, IQR, 61-73 years). Median preoperative serum creatinine was 1.8 mg/dL (IQR 1.6-2.3), and median eGFR was 39 mL/min/1.73 m^2 (IQR 21-46). With stenting, 11 of 43 patients (25.6%) derived a durable improvement in renal function at a median follow-up of 26 months (IQR 16-36 months). Responders enjoyed a 54% improvement in renal function from baseline, while nonresponders had a 7% decrement in renal function ($P < .0001$). Responders had a higher diastolic blood pressure, higher baseline serum creatinine, lower eGFR, and a steeper decline in renal function prior to RAS (Table). Kidney length, width, depth, and volume were not significantly different between responders and nonresponders (Table). Logistic regression analysis identified the rate of decline of renal function prior to stenting as the only independent predictor of improved renal function after RAS (odds ratio 16.7, 95% confidence interval 1.9-147.0; $P = .011$). Indeed, the rate of decline in eGFR per week was more than 18-fold greater for responders than nonresponders (3.4% vs 0.18% decline in eGFR per week; $P < .0001$).

Conclusions: The current study found that a steep decline in preoperative renal function portends a higher likelihood of renal salvage from RAS among patients with renal insufficiency. Incorporating this finding into patient selection may improve outcomes for RAS.

Variables	*Responders*	*Nonresponders*	P *value*
Age	71 years	68 years	.62
Gender	55% male	66% male	.43
Systolic blood pressure	172 mm Hg	145 mm Hg	.15
Diastolic blood pressure	86 mm Hg	73 mm Hg	.015
Serum creatinine	2.4 mg/dL	1.7 mg/dL	.025
eGFR	21 ml/min/1.72m^2	42 ml/min/1.72 m^2	.027
Percent decline in preop eGFR per week	3.4 % / week	0.18 % / week	< .0001
Proportion with solitary kidneys	18%	13%	.64

Continued.

Variables	*Responders*	*Nonresponders*	P *value*
Kidney Length	9.6 cm	9.8 cm	.72
Kidney Width	5.3 cm	5.4 cm	.20
Kidney Depth	5.0 cm	5.1 cm	.70
Kidney Volume	123 cm^3	129 cm^3	.53

Carotid Revascularization Outcomes Comparing Distal Filters, Flow Reversal, and Endarterectomy

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Introduction: Contradictory outcomes exist for different methods of carotid artery revascularization. Here we provide the comparative rates of adverse events in patients after carotid endarterectomy (CEA), carotid artery stenting (CAS) with distal protection (EPD), and CAS with flow reversal technology (FRS) from a single institution by various specialists treating carotid artery disease.

Methods: Procedural billing codes and the electronic medical records of patients undergoing carotid artery revascularization for carotid artery stenosis from February 2007 through March 2010 were utilized for data collection. Primary outcome was the incidence of stroke, MI, or death after CEA and CAS. The choice of therapy was determined by the individual practitioner with some specialists providing both CAS and CEA (5/14). Baseline characteristics were examined for effect on outcome. Planned comparisons between and within groups were analyzed using χ^2, *t* tests, and ANOVA as appropriate.

Results: There were 495 total procedures divided into carotid endarterectomies (226), CAS with EPD (216), and CAS with FRS (53). Preoperative comparisons of patient comorbidities were similar between cohorts. Forty-two percent of these patients were symptomatic from their carotid artery stenosis. Prior CEA was an indication for CAS over CEA ($P < .001$). Significantly fewer patients undergoing CEA were on preoperative antiplatelet therapy ($P < .001$) (Table I). There was no difference between groups in the overall composite end point of death, stroke, and MI (4%, 5.1%, 0%; $P = .1$) or any individual major adverse event (Table II). Overall, CAS with EPD had a statistically significant greater incidence of minor strokes when compared to CEA ($P = .031$) which was driven by the increased stroke risk for asymptomatic patients. Secondary endpoints occurred rarely (<2%) as listed in Table 3. There have been no reoperations or interventions in these patients to date within this institution.

Conclusions: We have established a similar and low incidence of MI, stroke, and death among patients undergoing CEA and CAS of whom approximately 40% were symptomatic. The flow reversal system has provided superior results in this series; however, its use was limited to 20% of the carotid artery stenting procedures. Still zero adverse events in this cohort make this an exciting technology that warrants a large-scale prospective comparative study.

Table I. Patient characteristics

	CEA	*CAS + EPD*	*CAS + FRS*	P *values*		
Overall	*n = 226*	*n = 216*	*n = 53*	*Overall*	*CEA/EPD*	*CEA/FRS*
Gender = Female	41%	38%	42%	.80	.55	.91
Age				.62	.65	.49
Median (years)	70	70	69			
80+ years	14%	21%	19%			
Symptomatic	41%	45%	32.7%	.27	.43	.26
Prior CEA	12%	29%	27%	<.001	<.001	.017
Hypertension	94%	92%	86%	.13	.50	.062
Hyperlipidemia	82%	87%	69%	.014	.15	.046
Renal Disease	9%	11%	2%	.084	.46	.067
Prior CVA	29%	22%	17%	.087	.090	.065
Prior TIA	31%	40%	46%	.067	.058	.062
Diabetes	35%	41%	36%	.44	.21	.85
Prior MI	15%	13%	21%	.42	.63	.31
Plavix therapy	35%	96%	96%	<.001	<.001	<.001