Published in final edited form as:
Circ Cardiovasc Interv. 2014 December ; 7(6): 829–836. doi:10.1161/CIRCINTERVENTIONS.114.001395.

Costs of Peri-Procedural Complications in Patients Treated with Transcatheter Aortic Valve Replacement: Results from the PARTNER Trial

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Abstract

Background—In patients with severe aortic stenosis, transcatheter aortic valve replacement (TAVR) improves survival compared with nonsurgical therapy but with higher in-hospital and lifetime costs. Complications associated with TAVR may decrease with greater experience and improved devices, thereby reducing the overall cost of the procedure. Therefore, we sought to estimate the impact of peri-procedural complications on in-hospital costs and length of stay of TAVR.

Methods and Results—Using detailed cost data from 406 TAVR patients enrolled in the PARTNER I trial, we developed multivariable models to estimate the incremental cost and length of stay associated with specific peri-procedural complications. Attributable costs and length of stay for each complication were calculated by multiplying the independent cost of each event by its frequency in the treatment group. Mean cost for the initial hospitalization was $79,619 ±

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The other authors report no potential conflicts.

40,570 ($50,891 excluding the valve); 49% of patients had ≥1 complication. Seven complications were independently associated with increased hospital costs, with major bleeding, arrhythmia and death accounting for the largest attributable cost per patient. Renal failure and the need for repeat TAVR, although less frequent, were also associated with substantial incremental and attributable costs. Overall, complications accounted for $12,475/patient in initial hospital costs and 2.4 days of hospitalization.

Conclusion—In the PARTNER trial, peri-procedural complications were frequent, costly, and accounted for approximately 25% of non-implant related hospital costs. Avoidance of complications should improve the cost-effectiveness of TAVR for inoperable and high-risk patients, but reductions in the cost of uncomplicated TAVR will also be necessary for optimal efficiency.

Keywords

transcatheter aortic valve replacement; costs; complications; valve

Transcatheter aortic valve replacement (TAVR) has emerged as an effective treatment for severe symptomatic aortic stenosis, with attendant improvements in both survival and quality of life compared with standard nonsurgical therapy in patients unsuitable for surgical valve replacement.[1–2] Although the short-term costs of TAVR are high compared with nonsurgical therapy, a formal economic evaluation demonstrated that the benefits of TAVR were achieved at an acceptable incremental cost to society, at least in the context of the U.S. health system.[3] With any emerging technology, complications should decrease with greater operator and site experience as well as improved devices. This pattern has already been evidenced in the early U.S. experience with TAVR, where stroke and bleeding complications appear to be lower than in the pivotal clinical trials.[4] Since complications were relatively common in the pivotal trials, the costs of treating these complications could have substantially impacted the overall cost of TAVR and its resulting cost-effectiveness relative to medical therapy and surgical AVR. Therefore, we sought to use detailed cost data from the Placement of AoRTic TraNscathetER Valve (PARTNER) Trial to estimate the impact of peri-procedural complications on the cost of TAVR. By doing so, we will better understand the potential economic benefits of avoiding such complications in the future and their impact on the cost-effectiveness of this rapidly evolving procedure.

METHODS

Study Population and Protocol

The study population was derived from patients with severe symptomatic aortic stenosis who were enrolled in either Cohort A or Cohort B of the PARTNER I trial and were randomized to and underwent TAVR. As previously described, patients enrolled in PARTNER had severe aortic stenosis (aortic valve area of <0.8 cm^2 with either a mean aortic valve gradient ≥40 mmHg or a peak aortic jet velocity ≥4.0 m/s); New York Heart Association (NYHA) class II or greater heart failure symptoms; and high surgical risk based on the Society for Thoracic Surgeons mortality risk score and other factors.[1, 5] Eligible patients who were high-risk but suitable for surgical AVR placement were randomized to

surgical AVR or TAVR.[5] Eligible patients who were deemed ineligible for cardiac surgery due to coexisting medical or anatomic conditions associated with a predicted probability of perioperative death or permanent disability ≥50% were randomized to medical therapy or TAVR.[1] Patients enrolled in Cohort A had TAVR performed via the transfemoral (TF) approach, if anatomy was favorable, or the transapical (TA) approach. All Cohort B patients were required to be treated via the TF approach. The study was approved by the institutional review board at each participating site, and all patients provided written informed consent.

Complications

In-hospital major complications were adjudicated by a centralized, clinical events committee according to specific definitions provided in Supplemental Table 1 and included the following: death, cerebrovascular accident (CVA) [major and minor], myocardial infarction, vascular complication [major and minor], renal insufficiency (serum creatinine >3 mg/dL), renal failure (need for renal replacement therapy), major bleeding, arrhythmia (high-degree AV block, atrial fibrillation or flutter, or ventricular tachycardia), new permanent pacemaker, repeat TAVR, and surgical AVR.

Index Hospitalization Costs

All costs were assessed from the perspective of the U.S. health care system and are reported in 2010 U.S. dollars. Costs that were incurred in years other than 2010 were converted to 2010 dollars using the Medical Care component of the Consumer Price Index. Costs were determined using a combination of hospital billing data and resource-based accounting methods, the precise details of which have been described previously.[3, 6] Previous studies have found this approach to correlate closely with costs derived from individual hospitals' microcost accounting systems.[7–8]

Each local study center recorded procedure duration and counts of major items used (e.g., valve prostheses, valvuloplasty balloons, temporary pacing catheters) for the TAVR procedure. Procedural costs were calculated by multiplying item counts by their respective unit prices, determined by the average acquisition costs at a sample of U.S. hospitals. The Edwards SAPIEN valve system was assumed to have an acquisition cost of $30,000. Ancillary costs for the catheterization laboratory (TF procedures) or operating room (TA procedures) were estimated based on a survey of PARTNER study hospitals and adjusted for observed procedure duration. For patients with billing data available (n=406, 78%), costs of the remainder of each index admission were calculated by multiplying all nonprocedural charges on the hospital bills by cost center-specific cost-to-charge ratios from each hospital's Medicare cost report.[7] For patients without billing data available (n=113, 22%), the remainder of costs were estimated using a linear regression model derived from the subjects with complete billing data, as previously described.[3, 6] Covariates in these models included intensive care unit and non–intensive care unit length of stay, in-hospital bleeding, and in-hospital death.

Physician fees for the initial consultation and daily care during the remainder of the initial hospital stay were derived from the Medicare fee schedule. Physician fees for the TAVR procedure included both a primary operator and surgical assistant and were assigned using

current reimbursement rates from the Medicare fee schedule for surgical AVR. Physician fees for cardiac anesthesia and intraoperative transesophageal echocardiography were assigned based on measured procedure duration.

Statistical Analysis

The goal of these analyses was to determine the independent impact of peri-procedural complications of TAVR on hospitalization costs and length of stay (LOS). Univariable differences in baseline demographic and clinical comorbidities between patients who developed any complication and those who did not were assessed with the chi-square test for categorical variables and Student's *t*-test for continuous variables. The unadjusted hospital cost and LOS for all patients and for the complication categories are presented as mean ± standard deviation. The unadjusted incremental costs and LOS associated with each complication were defined as the difference in mean cost (or LOS) between patients who developed each complication of interest and those who did not develop that specific complication within the entire study population.

We then estimated the incremental costs associated with each complication, adjusting for demographic and clinical variables. For this set of analyses, only patients with billing data were included. First, to identify potential confounders of the complication-cost relationship, we constructed a series of models to identify those factors that were either associated with in-hospital complications or were associated with costs among patients without complications. Specifically, we constructed a logistic regression model with backwards selection (with a threshold for retaining a variable of $p<0.1$) with “any complication” as the dependent variable and examined demographic and clinical factors associated with this outcome (Step 1). For these models, we considered the following potential predictors: age, sex, prior bypass graft surgery, prior angioplasty, renal disease (serum creatinine >2 mg/dL), ejection fraction <40%, oxygen-dependent lung disease, peripheral vascular disease, low body weight (body mass index <20 kg/m^2), diabetes mellitus, and Society of Thoracic Surgeons (STS) mortality risk score. Next, we evaluated the predictors of costs (using generalized linear models with log-link) among the subset of patients without complications in a similar manner with backward selection and the same potential covariates (Step 2).

We then constructed a multivariable linear regression model including the potential confounders identified in steps 1 and 2 along with age, sex, and all of the peri-procedural complications listed above (Step 3). For this model, we also considered the following potential interactions: arrhythmia*pacemaker, minor vascular complication*major bleeding, and major vascular complication*major bleeding. Model reduction was performed by backward covariate selection with a significance threshold of $p<0.1$ for retention. Model fit was assessed with R^2. The cost model was constructed using both log-transformed and untransformed costs as the dependent variable. Since both model fit and the magnitude of association between complications and costs were similar between the two models, we report only the results from the analysis using untransformed costs for ease of interpretation. Attributable costs for each complication were calculated by multiplying the independent cost of the event (derived from the regression model coefficients) by its frequency in the study

population. For the attributable cost calculations, we used the entire study population (i.e., patients with and without billing data available).

In addition to these parsimonious models, we also we constructed a saturated model including all peri-procedural complications of interest, adjusting for the demographic and clinical characteristics identified in steps 1 and 2. Finally, all analyses were repeated with LOS as the dependent variable. All analyses were performed with SAS 9.2 (SAS Institute, Cary, North Carolina).

RESULTS

Patient Population

Of the 1057 patients with severe aortic stenosis who were enrolled in the PARTNER randomized trial, 519 patients were randomized to and received TAVR (344 in Cohort A, 175 in Cohort B), of which 406 (78%) had complete index hospital bills available. Patients with billing data were generally similar to those without billing data (Supplemental Table 2). Patients with missing data were more likely to have been enrolled in Cohort B, had more kidney and lung disease but lower rates of peripheral vascular disease. Rates of all complications were similar between groups except that patients with missing data were more likely to have major bleeding events (missing vs. not: 20% vs. 10%, p=0.005; although vascular complications were similar between groups).

The mean age of the analytic population was 83 years, and 47% were female (Table 1). The mean aortic valve area was 0.65 cm^2, and 94% were classified as NYHA Class III–IV. Forty-nine percent of the patients had at least one peri-procedural complication during the index hospitalization. The baseline characteristics of patients with vs. without a complication are shown in Table 1. Patients with a complication were more likely to be female, less likely to have undergone prior coronary bypass surgery, and were more likely to be Cohort B patients (i.e., inoperable).

Observed Complication Rate and Associated Resource Use

The distribution of specific peri-procedural complications is shown in Table 2. Overall, 254/519 (48.9%) of patients experienced at least one in-hospital complication. Twenty-one percent of patients experienced 1 complication, 10% had 2, and 18% had 3 or more complications during the index hospitalization. The most common complications were major arrhythmias (17%), major vascular complications (13%), major bleeding (12%), and minor vascular complications (8%).

The mean cost of the index hospitalization for all patients was $79,619 ($50,891 after excluding the cost of the valve), and the mean LOS was 10.4 days. Patients who experienced any complications had substantially higher costs and LOS compared with those who did not develop a complication, with an unadjusted incremental cost of $33,196 and an incremental LOS of 6.6 days (Table 3). The unadjusted incremental cost of complications ranged from -$5732 (for minor stroke) to $75,388 (for death) and $135,017 (for repeat TAVR). The unadjusted incremental LOS ranged from 2.1 days (for minor vascular complications) to 13.4 and 34.9 days for death and renal failure requiring dialysis, respectively.

Adjusted Incremental Hospital Costs

In a multivariable model that adjusted for demographic and clinical characteristics, 7 complications were independently associated with increased hospitalization costs (Table 4). A repeat TAVR procedure was associated with nearly $120,000 in additional hospitalization costs. Renal failure and death were also very expensive, with adjusted incremental costs of approximately $68,000 and $42,000, respectively. Major bleeding, need for surgical AVR, major stroke, and the occurrence of a major arrhythmia were all also associated with increased hospitalization costs. The model demonstrated good fit, with an R^2 of 0.41. In the saturated model that included all complications, the incremental cost estimates for these complications were similar as was the model fit (R^2=0.41). Attributable cost calculations demonstrated that major bleeding was the most important driver of initial hospital cost for TAVR, accounting for $3990 per patient of the total hospitalization costs (Table 4). Arrhythmias, death, and renal failure were also important drivers of total hospitalization costs for TAVR, with attributable costs of $2786, $2104, and $1967 per patient, respectively. Although repeat TAVR was associated with a high incremental cost, since its frequency was low, it was not a major contributor to total hospitalization costs. Overall, $12,475 of the total hospitalization cost of TAVR was attributable to peri-procedural complications, which represents 15.7% of the total hospitalization cost and 24.5% of the non-implant related costs of TAVR.

Adjusted Incremental LOS

A total of 6 complications were independently associated with increased length of stay, after adjusting for demographic and clinical characteristics, (Table 5). These included death, renal failure, major bleeding, vascular complications, major arrhythmia, and pacemaker implantation. Of note, there was a significant interaction between major bleeding and both major and minor vascular complications. Major bleeding episodes in the absence of major vascular complications were associated with an incremental LOS of 14.3 days. In contrast, major bleeding episodes that occurred in conjunction with a major vascular complication were associated with an incremental LOS of 3.9 days. Major and minor vascular complications in the absence of major bleeding were not associated with significantly higher LOS. The model demonstrated adequate fit, with an R^2 of 0.26. In the saturated model that included all complications, model estimates for the LOS coefficients were similar as was the model fit (R^2=0.29).

Attributable LOS calculations demonstrated that major bleeding complications (with or without vascular complications) were the most important drivers of LOS for TAVR, with 1.0 days of the total LOS attributable to major bleeding complications (both with and without vascular complications; Table 4). Overall, 2.4 days of the total LOS for TAVR were attributable to peri-procedural complications, which represents 23.1% of the total length of stay.

DISCUSSION

Formal economic analyses based on the PARTNER trial data have demonstrated that, from the perspective of the U.S. healthcare system, TAVR is reasonably cost-effective for both

inoperable[3] and high risk[6] patients with aortic stenosis. However, some analysts have raised important concerns about the value of this technology—particularly for patients with multiple comorbidities (who may not derive substantial survival benefit from the procedure) and for patients at only moderate risk of surgical complications (for whom TAVR may offer little clinical and no economic advantage).[9–10] Moreover, even in circumstances where the value of TAVR from a societal perspective is well-accepted, concerns have been raised about the financial viability of TAVR from the hospital perspective.[11] Until the acquisition cost of the valve decreases, strategies to reduce the frequency of complications may help to limit the up-front costs and improve the overall cost-effectiveness of TAVR. In the PARTNER trial, nearly half of all patients had at least one complication. As such, a reduction in these complications could have a substantial impact on the overall costs of the initial hospitalization for TAVR and on the ultimate cost-effectiveness of the procedure.

Using detailed cost data from patients treated with TAVR in the PARTNER trial, we found that peri-procedural complications were associated with substantial costs and increased LOS both on a per event basis (i.e., incremental cost or LOS) as well as on a per hospitalization basis (i.e., attributable cost or LOS). With respect to specific complications, it appears that bleeding, death, arrhythmias, and post-procedure renal failure led to the greatest increase in overall hospital costs. As such, interventions targeted to reduce these complications would be expected to yield the greatest benefit in terms of improving the cost-effectiveness of TAVR. Overall, complications accounted for $12,475/patient in initial hospital costs, which represents 25% of non-implant related hospital costs. However, since 75% of non-implant hospitalization costs were not related to complications, reductions in the cost of uncomplicated TAVR (either by reducing post-procedure LOS or through a “minimalist approach” to the implant procedure, itself) will also be necessary to optimize the value of the technology.

Importantly, several studies have already demonstrated important reductions in TAVR complications with greater operator and institutional experience.[4, 12–13] For example, in a single center Canadian study, Toggweiler and colleagues demonstrated that the risk of major vascular complications decreased from 8% in their earliest experience to 1%.[13] More recently, initial data from the U.S. TVT registry demonstrated that the rate of major bleeding among 7710 TAVR procedures was 6.4%—substantially lower than the rate observed in the PARTNER A and B randomized trials.[4] While the definitions of complications collected in the TVT registry differ from those used in the PARTNER trial, if we assume that the incremental costs of complications have remained stable, the costs attributable to complications would have decreased from $12,475 to $9787/patient (Supplemental Table 3). Whether this assumption is correct is unknown, however, and further analysis of costs specifically within the TVT registry will be required to truly estimate the impact of changing complication rates on the costs of TAVR.

With respect to our attributable cost estimates, it is important to note that reductions in certain complications may actually have a multiplicative effect on overall hospital cost since they may actually mediate other complications. For example, reductions in bleeding may result in reductions in renal failure or short-term mortality as well.[14–15] As such, the impact of any particular intervention to reduce complications on overall hospital cost could be

magnified. The economic impact of these complications from the hospital's perspective is potentially even more complex. For example, under the current Medicare diagnosis-related group-based reimbursement system, some complications that lead to substantial increases in hospital costs also result in reclassification of patients into a higher paying diagnosis-related group (e.g., acute renal failure, stroke). Nonetheless, since the incremental cost of these complications is generally much higher than the payment differential, hospitals will still derive meaningful economic benefit from efforts to reduce these complications.

Beyond providing a better understanding of the impact of complications on the cost of TAVR, these analyses provide important data that can be used as inputs for simulation models designed to assess the cost-effectiveness of TAVR. To date, such models have estimated the cost of TAVR-related complications based on extrapolation from other interventional procedures (e.g., percutaneous coronary intervention)[16–17] or from the Medicare fee schedule.[9] Comparison of these values with our estimates derived specifically from patients undergoing TAVR demonstrates a number of discrepancies. For example, in our study, the incremental cost of bleeding complications with TAVR was $32,869 as compared with $3393 based on patients undergoing percutaneous coronary interventions[16] or $12,352 based on Medicare data.[9] In the future, models that use cost estimates derived from patients actually undergoing TAVR should yield more valid cost-effectiveness estimates than has been possible previously.

There are a number of potential limitations to our analyses that merit further discussion. First, cost data were available for only 406 patients who had undergone TAVR, which limits our ability to obtain precise estimates of the incremental cost associated with some of the less common complications (e.g., repeat TAVR, pacemaker placement). As such, these estimates have wide confidence intervals and will need to be examined in larger datasets when these data are available. However, a key strength of our analyses is the ability to use detailed resource utilization data collected as part of the clinical trial in our costing methodology, providing a level of granularity that would not be possible using claims data. Moreover, by performing our cost analysis within the context of a carefully monitored clinical trial, we were able to take advantage of carefully adjudicated endpoints, which are unlikely to be achieved with administrative data. Second, all patients in our study were enrolled in a clinical trial, representing the earliest experience with TAVR at most sites. Consequently, it is likely that the incidence of complications was higher than would be seen with more experience and that costs were increased for uncomplicated hospitalizations as well, due to the novelty of the procedure. Nonetheless, neither of these factors would be expected to influence the incremental cost associated with specific complications, which was the focus of our study. Third, our analyses are limited to the in-hospital costs of TAVR complications. While certain peri-procedural complications, such as stroke and renal failure, are likely to increase long-term costs as well, these costs are not directly relevant to U.S. hospitals that are currently reimbursed mainly on an episode of care basis. In the future, additional analyses of the long-term costs associated with peri-procedural complications could provide a more comprehensive assessment of the economic and clinical impact of these complications from a societal perspective. Finally, peri-procedural complications were defined according to the PARTNER trial protocol, which was designed prior to the development of either Valve Academic Research Consortium-2 (VARC-2) definitions.[18]

While many of these endpoint definitions are similar between the protocol and VARC-2 (e.g., stroke and myocardial infarction), others differ (e.g., renal failure and major bleeding). We have outlined the specific definitions for these complications in the Supplemental Material. Were we to have used the VARC-2 definitions for our study, both the frequency of complications and their associated cost estimates would likely be altered.

In conclusion, based on data from the PARTNER trial, peri-procedural complications after TAVR were frequent, costly, and accounted for ~25% of non-implant related hospital costs. On a per event basis, the most costly complications were repeat TAVR, renal failure, and in-hospital death. Although avoidance of complications should improve the cost-effectiveness of TAVR for inoperable and high-risk patients, reductions in the cost of uncomplicated TAVR will also be necessary to optimize the value of this rapidly evolving procedure.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Clinical Trial Registration Information: ClinicalTrials.gov: NCT00530894

Sources of Funding: The PARTNER trial was sponsored by Edwards Lifesciences. This current study was self-funded, and the funding organization for the trial did not play a role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, review, or approval of the manuscript. Dr. Arnold is supported by a Career Development Grant Award (K23 HL116799) from the National Heart, Lung, and Blood Institute.

Disclosures: MRR: support from Edwards Lifesciences and Medtronic; consulting income from Medtronic; SKK: consulting income from Edwards Lifesciences, Medtronic; advisory board member Thubrikar Aortic Valve, Inc., Paieon Medical, and St. Jude Medical; VHT: research support from Edwards Lifesciences, Sorin Medical; consulting income from DirectFlow, St. Jude Medical, Sorin Medical; royalties/intellectual property rights from Apica; MBL: travel reimbursements from Edwards Lifesciences for activities related to his position on the Executive Committee of the PARTNER Trial; MJM: travel reimbursements from Edwards Lifesciences for activities related to his position on the Executive Committee of the PARTNER Trial; DJC: research support from Edwards Lifesciences, Medtronic, Boston Scientific, Abbott Vascular, MedRad, Merck/Schering-Plough, and Eli Lilly-Daiichi Sankyo; consulting income from Schering-Plough, Eli Lilly, Medtronic, and Cordis; and speaking honoraria from Eli Lilly, The Medicines Company, and St. Jude Medical.

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Table 1

Baseline characteristics

Characteristic	All Patients n=519	Any Complication		
		Yes n=254	No n=265	p-value
Age (years)	83.4±7.5	84.1±7.3	82.8±7.6	0.053
Female	47	52	41	0.010
Prior bypass surgery	39	32	46	0.002
Prior angioplasty	31	28	34	0.12
Peripheral vascular disease	39	42	37	0.22
Creatinine (mg/dL)	1.30±0.48	1.31±0.49	1.28±0.47	0.54
Renal disease (Cr ≥2)	19	21	17	0.22
Ejection fraction (%)	52.9±13.7	53.7±14.0	52.2±13.3	0.35
Ejection fraction <40%	17	17	17	0.98
Oxygen-dep. lung disease	13	14	13	0.56
Body mass index (kg/m2)	27.1±7.2	26.9±7.1	27.3±7.4	0.50
Body mass index <20 kg/m2	10	11	9	0.65
Diabetes mellitus	39	38	40	0.67
Major arrhythmia	48	50	46	0.41
Hemoglobin (mg/dL)	11.7±1.6	11.5±1.5	11.8±1.6	0.026
Systolic BP (mmHg)	127.3±22.0	128.4±22.1	126.3±21.9	0.28
Mini Mental Status Exam (points)	26.8±3.4	26.8±3.4	26.8±3.4	0.98
6MWT attempted	57	52	62	0.035
6MWT distance (m)	156.6±109.4	153.1±98.0	159.4±117.9	0.63
NYHA class				0.17
2	6	8	5	
3	44	42	46	
4	50	50	49	
Mean AV gradient (mmHg)	43.5±14.8	43.9±15.1	43.1±14.5	0.53
Aortic valve area (cm^2)	0.65±0.19	0.64±0.18	0.66±0.20	0.26
STS Predicted Mortality (%)	11.6±4.3	11.9±4.8	11.4±3.8	0.17
Cohort A	66	57	76	<0.001
Transfemoral approach	80	81	80	0.84

Values are expressed as mean ± SD or %.

Table 2

Observed in-hospital complication rates

Complication	Frequency n(%)
Any complication	254 (48.9%)
Number of complications	
0	265 (51.1%)
1	111 (21.4%)
2	52 (10.0%)
≥3	91 (17.5%)
Death	26 (5.0%)
Major stroke	17 (3.3%)
Minor stroke	7 (1.3%)
Myocardial infarction	1 (0.2%)
Major vascular complication	67 (12.9%)
With major bleed	39 (7.5%)
Without major bleed	28 (5.4%)
Minor vascular complication	44 (8.5%)
Major bleeding	63 (12.1%)
Renal insufficiency	25 (4.8%)
Renal failure requiring dialysis	15 (2.9%)
Arrhythmia	90 (17.3%)
Permanent pacemaker	20 (3.9%)
Repeat TAVR	3 (0.6%)
Surgical AVR	8 (1.5%)

Circ Cardiovasc Interv. Author manuscript; available in PMC 2015 December 01.

Table 3

Unadjusted cost and length of stay associated with specific complications

	Mean Cost ($)	Incremental Cost of Complication*	Mean LOS (days)	Incremental LOS of Complication*
Any complication	$96,679 ± 51,873	$33,196	14.0 ± 13.4	6.6
Death	$149,956 ± 86,267	$75,388	23.1 ± 21.7	13.4
Major stroke	$108,319 ± 45,062	$31,030	17.2 ± 10.3	7.0
Minor stroke	$72,621 ± 28,917	−$5,732	7.6 ± 4.8	2.8
Major vascular complication	$102,294 ± 57,800	$27,156	12.6 ± 11.4	2.5
Minor vascular complications	$83,897 ± 33,217	$6,095	12.3 ± 10.2	2.1
Major bleeding	$117,383 ± 70,840	$43,374	17.3 ± 19.8	7.7
Renal insufficiency	$98,834 ± 42,065	$21,450	13.8 ± 10.2	3.6
Renal failure	$219,553 ± 87,055	$144,473	44.4 ± 29.0	34.9
Arrhythmia	$100,357 ± 54,988	$26,360	15.1 ± 13.0	5.7
Permanent pacemaker	$93,395 ± 35,693	$15,613	13.3 ± 9.1	3.1
Repeat TAVR	$212,634 ± 2,941	$135,017	19.0 ± 12.7	8.7
Surgical AVR	$126,340 ± 50,820	$48,901	16.6 ± 11.2	6.3

Incremental cost (and LOS) refers to the difference in mean cost (or LOS) between patients with vs. without the complication of interest

Table 4

Adjusted incremental hospital costs associated with treating patients with different patient factors and particular complications of TAVR, as obtained from multivariable regression models

	Saturated Model*			Reduced Model*		
Complication	**Incremental Cost**	**95% CI**	**Attributable Cost**	**Incremental Cost**	**95% CI**	**Attributable Cost**
Death	$42,199	($26,001 to $58,397)	$2,114	$42,008	($25,981 to $58,035)	$2,104
Major stroke	$15,231	(−$2,953 to $33,415)	$499	$16,272	(−$1,699 to $34,243)	$533
Minor stroke	$3,120	(−$25,531 to $31,772)	$42			
Major vascular	−$4,358	(−$17,407 to $8,690)	−$563			
Minor vascular	$5,424	(−$6,499 to $17,348)	$460			
Major bleeding	$35,823	($21,868 to $49,778)	$4,348	$32,869	($22,010 to $43,728)	$3,990
Renal insufficiency	$1,270	(−$15,258 to $17,797)	$61			
Renal failure	$69,097	($47,366 to $90,828)	$1,997	$68,051	($46,805 to $89,297)	$1,967
Arrhythmia	$16,475	($7,283 to $25,667)	$2,857	$16,067	($7,366 to $24,768)	$2,786
Pacemaker	−$7,170	(−$26,279 to $11,939)	−$276			
Repeat TAVR	$119,766	($73,106 to $166,426)	$692	$119,905	($74,311 to $165,499)	$693
Surgical AVR	$27,477	($2,873 to $52,081)	$424	$26,070	($1,682 to $50,458)	$402
Total cost of complications			**$12,655**			**$12,475**

*Models adjusted for age, sex, prior bypass surgery, peripheral vascular disease, diabetes, and STS mortality risk score R^2 of saturated model=0.41: R^2 of reduced model=0.41

Table 5

Adjusted incremental length of stay associated with treating patients with different patient factors and particular complications of TAVR, as obtained from multivariable regression models

	Saturated Model*			Reduced Model*		
Complication	**Incremental LOS (days)**	**95% CI**	**Attributable LOS**	**Incremental LOS (days)**	**95% CI**	**Attributable LOS**
Death	4.4	(−0.1 to 9.0)	0.2	4.7	(0.2 to 9.2)	0.2
Major stroke	2.5	(−2.6 to 7.6)	0.1			
Minor stroke	-1.4	(−9.4 to 6.6)	0.0			
Major vascular + major bleed	3.5	(0.0 to 7.0)	0.3	3.9	(0.5 to 7.3)	0.3
Major vascular − major bleed	−1.7	(−6.1 to 2.8)	−0.1	−1.6	(−6.0 to 2.8)	−0.1
Minor vascular	0.9	(−2.5 to 4.2)	0.1	0.8	(−2.5 to 4.1)	0.1
Major bleeding – major vascular	14.3	(8.7 to 19.8)	0.7	14.3	(8.9 to 19.8)	0.7
Renal insufficiency	0.9	(−3.7 to 5.5)	0.0			
Renal failure	18.3	(12.2 to 24.3)	0.5	18.4	(12.5 to 24.3)	0.5
Arrhythmia	4.4	(1.9 to 7.0)	0.8	4.2	(1.8 to 6.6)	0.7
Pacemaker	−3.3	(−8.6 to 2.0)	−0.1			
Repeat TAVR	6.9	(−6.1 to 19.9)	0.0			
Surgical AVR	2.1	(−4.7 to 9.0)	0.0			
Total LOS impact of complications (days)			**2.5**			**2.4**

*Models adjusted for age, sex, prior bypass surgery, peripheral vascular disease, diabetes, and STS mortality risk score R^2 of saturated model=0.30; R^2 of reduced model=0.29