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ORIGINAL ARTICLE

Economics of Minimalist Transcatheter Aortic Valve Replacement: Results From the 3M-TAVR Economic Study

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BACKGROUND: The 3M-TAVR trial (3M-Transcatheter Aortic Valve Replacement) demonstrated the feasibility and safety of next-day hospital discharge after transfemoral TAVR with implementation of a minimalist pathway. However, the economic impact of this approach is unknown. Therefore, we evaluated costs for patients undergoing minimalist TAVR compared with conventional TAVR.

METHODS: We used propensity matching to compare resource utilization and costs (from a US health care system perspective) for patients in the 3M-TAVR trial with those for transfemoral TAVR patients enrolled in the contemporaneous S3i trial (PARTNER SAPIEN-3 Intermediate Risk). Procedural costs were estimated using measured resource utilization for both groups. For the S3i group, all other costs through 30-day follow-up were assessed by linkage with Medicare claims; for 3M, these costs were assessed using regression models derived from S3i cost and resource utilization data.

RESULTS: After 1:1 propensity matching, 351 pairs were included in our study (mean age 82, mean Society of Thoracic Surgery risk score 5.3%). There were no differences in death, stroke, or rehospitalization between the 3M-TAVR and S3i groups through 30-day follow-up. Index hospitalization costs were $10 843/patient lower in the 3M-TAVR cohort, driven by reductions in procedure duration, anesthesia costs, and length of stay. Between discharge and 30 days, costs were similar for the 2 groups such that cumulative 30-day costs were $11 305/patient lower in the 3M-TAVR cohort compared with the S3i cohort ($49 425 versus $60 729, 95% CI for difference $9378 to $13 138; $P<0.001$).

CONCLUSIONS: Compared with conventional transfemoral TAVR, use of a minimalist pathway in intermediate-risk patients was associated with similar clinical outcomes and substantial in-hospital cost savings, which were sustained through 30 days.

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Key Words: costs and cost analysis ■ hospital ■ hospitalization ■ length of stay ■ Medicare ■ transcatheter aortic valve replacement

Transcatheter aortic valve replacement (TAVR) was initially developed as a less invasive alternative to surgical aortic valve replacement for high risk or inoperable patients.[1] Subsequent innovations in device design and deployment have made TAVR even less invasive and have enabled the development of the

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WHAT IS KNOWN

- Innovations in device design and deployment have made transcatheter aortic valve replacement (TAVR) even less invasive and have enabled the development of the minimalist approach.
- The 3M-TAVR trial (3M-Transcatheter Aortic Valve Replacement) demonstrated the feasibility and safety of next-day hospital discharge after transfemoral TAVR with implementation of a minimalist pathway.
- However, the economic impact of this approach is unknown.

WHAT THE STUDY ADDS

- Compared with conventional transfemoral TAVR, use of a minimalist pathway was associated with similar clinical outcomes and in-hospital cost savings of $10 843, which were sustained through 30 days (cumulative 30-day costs $11 305/patient lower in the 3M-TAVR cohort compared with the S3i cohort [PARTNER SAPIEN-3 Intermediate Risk]).
- These findings suggest that continued emphasis on a minimalist approach to TAVR is likely to provide substantial benefits to patients, hospitals, and the health care system.

Nonstandard Abbreviations and Acronyms

TAVR	transcatheter aortic valve replacement

minimalist approach.[2] The 3M (multidisciplinary, multimodality, but minimalist) TAVR trial evaluated a clinical pathway designed to facilitate next-day discharge home in patients undergoing TAVR and demonstrated excellent safety and efficacy outcomes.[2] However, the economic implications of a standardized minimalist clinical pathway for TAVR remain unclear. As TAVR is increasingly perceived as a low margin procedure in the United States, understanding the economic impact of minimalist TAVR is important, because in the current episode of care-based payment system, the financial viability of TAVR programs depends on the cost of the TAVR hospitalization relative to reimbursement.

Although TAVR has been shown to be cost-effective relative to surgical aortic valve replacement for certain high- and intermediate-risk patients,[3,4] these analyses were performed from a health care system perspective, and their results were driven largely by follow-up cost savings, which accrue mainly to the third-party payer rather than the hospital itself.[5] Prior studies have demonstrated cost savings with a minimalist approach compared with conventional TAVR.[6–8] However, these studies have generally been single-center reports based on older valve technologies, have focused only on in-hospital costs, and have used simple pre-post comparisons. Given these limitations, there is a need to quantify the impact of minimalist TAVR on costs in a more representative setting across multiple hospital sites and over a longer time horizon to ensure that any early cost savings do not simply represent cost shifting to the outpatient setting.

To address this gap in knowledge, we sought to examine the economic impact of minimalist TAVR by comparing the in-hospital and 30-day costs of patients from 2 recent clinical trials that enrolled similar patients using similar TAVR devices—the 3M-TAVR trial and the S3i trial (PARTNER SAPIEN-3 Intermediate Risk). These results can inform the implementation of minimalist TAVR and help centers develop cost-effective TAVR programs more broadly.

METHODS

Patient Population and Study Design

The minimalist TAVR cohort for our study was derived from the 3M-TAVR trial, which enrolled patients with severe, symptomatic aortic stenosis at increased surgical risk from 13 North American centers between March 2015 and April 2017. All patients received balloon-expandable valves, and the design and primary outcome of 3M-TAVR have been described previously.[2] The study design for the 3M-TAVR trial was approved by the institutional review board at each participating site, and the economic analysis of the S3i trial was approved by the institutional review board at Saint Luke's Hospital of Kansas City. All patients provided informed consent before participation. Patients were excluded if they were not suitable for percutaneous iliofemoral vascular access or had life expectancy <3 years unrelated to their aortic valve disease. The data that support the findings of this study, the methods used in the analysis, and materials used to conduct the research will not be made available due to contractual arrangements with the study sponsor.

The 3M-TAVR Clinical Pathway consisted of a minimalist approach to the TAVR procedure, facilitated postprocedure recovery, and criteria-driven discharge. The minimalist procedural approach included local anesthesia with minimal or no procedural sedation, minimal central lines, no urinary catheter or pulmonary artery catheter, and transthoracic echocardiography perioperatively. Facilitated postprocedure recovery was notable for removal of any central and arterial lines within 2 hours after the procedure followed by bedrest for 4 hours and nursing-led mobilization. Discharge criteria included a review of the transthoracic echocardiography; absence of persistent conduction delay, vascular access complications, or laboratory contraindications; and return to baseline mobilization and hydration status. All patients received either a SAPIEN-XT or SAPIEN-3 balloon-expandable valve (Edwards Lifesciences, Irvine, CA).

Our standard TAVR cohort included patients from the PARTNER S3i trial, which was a single-arm prospective continuing access registry that enrolled patients with severe, symptomatic aortic stenosis at intermediate surgical risk from 51 centers between February and December 2014, all of whom underwent TAVR using the SAPIEN-3 valve.[9] We chose the S3i trial as a comparator because it enrolled during a similar time frame as 3M-TAVR, patients had a similar mean age and Society of Thoracic Surgery risk, and patients received the same generation

TAVR device. Key exclusion criteria for the S3i trial included bicuspid aortic valve, severe aortic regurgitation, left ventricular ejection fraction <20%, severe renal insufficiency, and life expectancy <2 years. For this study, we also excluded patients who could not be linked with Medicare claims (which served as the source of cost data) and those who underwent nontransfemoral TAVR (since the 3M-TAVR cohort included only transfemoral TAVR).

Costs

The economic analyses were performed from the perspective of the US health care system and are reported in 2019 US dollars. Although the majority of 3M sites were in Canada, costs were calculated in US dollars based on measured resource utilization, which was similar between the 2 systems. Costs for the initial TAVR procedure were calculated using resource-based accounting based on procedure duration, contrast volume, and intraprocedural complications recorded for both the 3M-TAVR and S3i cohorts. This included the cost of the TAVR valve (assumed to be $32 500), ancillary costs for the cardiac catheterization laboratory (adjusted for observed procedural time), and the cost of resources used for an uncomplicated procedure (eg, sheaths, temporary pacing catheters, etc), as well as those used for the treatment of specific complications (eg, major vascular complication, permanent pacemaker insertion). Unit costs for procedural resources for all sites were determined based on the average acquisition cost at Saint Luke's Hospital (Kansas City, MO). Utilization was measured at each site for each patient and then multiplied by these unit costs to calculate standardized costs for the initial TAVR procedure.

To calculate all remaining costs (including nonprocedure related index hospitalization costs, physician fees, and all health care related costs between discharge and 30-day follow-up), probabilistic matching was used to link S3i trial patients with Medicare claims data, and costs were based on actual Medicare payments. For the 3M-TAVR cohort, nonprocedure related costs for the index hospitalization and physician fees were estimated based on regression models derived from the Medicare-linked S3i cohort (Table S1). Costs incurred between discharge and 30-day follow-up (including physician fees, outpatient services, repeat hospitalizations, rehabilitation/skilled nursing facility care, and hospice/home health services) were imputed based on separate regression models based on the Medicare-linked S3i cohort (Table S1). To reduce the impact of any extreme outliers, index hospitalization costs were trimmed at the 99th percentile separately for each cohort, and follow-up costs were trimmed at the 99th percentile for the overall cohort. Total costs were calculated by summing the trimmed index hospitalization and follow-up costs. In addition, we conducted a sensitivity analysis using the same regression models to calculate nonprocedure related index hospital costs and follow-up costs for the S3i group and the 3M-TAVR group.

Statistical Analysis

Continuous variables are described as mean±SD, and categorical variables are described as counts and percentages. Given the observational study design, propensity matching was used to reduce confounding in statistical comparisons between the 3M-TAVR and S3i cohorts. First, a logistic regression model was created based on baseline characteristics (all variables listed in Table 1, unless otherwise noted) to calculate a propensity score for each patient signifying the probability that a patient was in the 3M-TAVR cohort. Next, patients from the S3i cohort were matched with patients in the 3M-TAVR cohort using a 1:1 greedy matching algorithm with a caliper limit of 0.20. Standardized differences were then calculated to confirm the adequacy of the propensity matching; a standardized difference <0.10 was considered to represent adequate covariate balance.

All comparisons of clinical outcomes, resource utilization, and costs were based on the propensity-matched sample. Clinical outcomes were compared between the 3M-TAVR and S3i cohort using χ^2 or Fisher exact tests. For costs, 95% CIs and *P* values for differences were derived via bootstrapping (1000 replicates) of the 3M-TAVR cohort to account for sampling variability.

Table 1. Baseline Characteristics of the Propensity-Matched 3M-TAVR and S3i Populations

	3M-TAVR (n=351)	S3i (n=351)	Standardized difference (3M-S3i)
Age, y	81.8±7.6	81.9±6.8	−0.017
Male sex, n (%)	210 (59.8)	212 (60.4)	−0.012
STS risk score, %	5.3±2.5	5.2±1.3	0.015
BMI, kg/m^2	27.8±5.8	28.0±5.9	−0.045
Prior CABG, n (%)	83 (23.6)	81 (23.1)	0.013
Prior PCI, n (%)	103 (29.3)	100 (28.5)	0.019
Prior stroke, n (%)	28 (8.0)	28 (8.0)	0.000
Peripheral vascular disease, n (%)	45 (12.8)	49 (14.0)	−0.033
Diabetes, n (%)	91 (25.9)	91 (25.9)	0.000
COPD, n (%)	77 (21.9)	78 (22.2)	−0.007
Atrial fibrillation, n (%)	77 (21.9)	79 (22.5)	−0.014
Permanent pacemaker, n (%)	55 (15.7)	53 (15.1)	0.016
LV ejection fraction, %	56.6±9.4	56.9±13.9	−0.028
Porcelain aorta, n (%)	1 (0.3)	1 (0.3)	−0.015
Renal insufficiency, n (%)	12 (3.4)	13 (3.7)	−0.047
Carotid disease, n (%)	20 (5.7)	24 (6.8)	0.033
Current smoker, n (%)	12 (3.4)	10 (2.8)	−0.028
KCCQ-OS	53.1±22.4	53.3±21.8	−0.005
SF12 PCS	34.2±9.7	35.0±8.4	−0.080
SF12 MCS	50.0±10.9	49.6±10.7	0.034
From academically affiliated site*	351 (100.0)	267 (76.1)	0.793

BMI indicates body mass index; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; KCCQ-OS, Kansas City Cardiomyopathy Questionnaire Overall Summary Score; LV, left ventricle; MCS, mental component score; PCI, percutaneous coronary intervention; PCS, physical component score; S3i, PARTNER SAPIEN-3 Intermediate Risk; STS, Society of Thoracic Surgeons; and TAVR, transcatheter aortic valve replacement.

*Variable not included in propensity score model.

RESULTS

Sample and Patient Characteristics

A total of 411 patients were included in the 3M-TAVR trial. Of the 1077 patients who were enrolled in the S3i

trial, 126 were excluded because of nontransfemoral access, and an additional 223 were excluded because they were unable to be linked to Medicare claims, leaving 728 patients in the S3i cohort (Figure S1). At baseline, patients in the 3M-TAVR and S3i groups were similar with respect to age, Society of Thoracic Surgery Risk score, and health status as assessed by the Kansas City Cardiomyopathy Questionnaire-12 overall summary score, as well as many comorbidities (Table S2). However, compared with the S3i cohort, 3M-TAVR patients were less likely to have peripheral vascular disease (12% versus 24%), atrial fibrillation (20% versus 38%), or renal insufficiency (3% versus 8%). After propensity matching, a total of 702 patients (351 matched pairs) remained in our study, and all measured covariates were well balanced (Table 1; Figure S2).

Clinical Outcomes

Clinical outcomes for the propensity-matched 3M-TAVR and S3i groups are summarized in Table 2. During the index hospitalization, there were no significant differences between the 3M-TAVR and S3i cohorts in terms of death (0.9% versus 0.3%), stroke (0.6% versus 2.0%), or myocardial infarction (0% versus 0.3%). However, patients in the 3M-TAVR group were less likely to receive a new permanent pacemaker (3.4% versus 8.3%) or to experience a major vascular complication (1.7% versus 5.4%) compared with the S3i group. Other adverse events, including major bleeding, acute kidney injury, and repeat valve procedures, were similar between the 2 groups.

After the index hospitalization, 3M-TAVR patients were more likely to be discharged home (96% versus 89%), while S3i patients were more likely to be discharged to a rehabilitation, skilled nursing, or extended care facility (11% versus 1%, $P<0.001$). Between discharge and 30-day follow-up, there were no differences between the 2 groups in rates of death, stroke, myocardial infarction, repeat valve procedures, or rehospitalization.

Table 2. Clinical Outcomes

	3M-TAVR	S3i	*P* value
In-hospital outcomes, n (%)			
Death	3 (0.9)	1 (0.3)	0.623
Any stroke	2 (0.6)	7 (2.0)	0.176
MI	0 (0.0)	1 (0.3)	1.000
In-hospital adverse events, n (%)			
Repeat valve procedure	2 (0.6)	0 (0.0)	0.499
Permanent pacemaker	12 (3.4)	29 (8.3)	0.006
Major bleeding	5 (1.4)	13 (3.7)	0.056
Acute kidney injury	0 (0.0)	1 (0.3)	NA
Major vascular complication	6 (1.7)	19 (5.4)	0.008
Atrial fibrillation	0 (0.0)	12 (3.4)	<0.001
Discharge location, n (%)			<0.001
Home	338 (96.3)	312 (88.9)	
Rehabilitation/SNF/extended care	5 (1.4)	38 (10.8)	
Deceased	3 (0.9)	1 (0.3)	
Other	5 (1.4)	0 (0.0)	
Discharge to 30 d, n (%)			
Death	1 (0.3)	2 (0.6)	1.000
Stroke	1 (0.3)	0 (0.0)	1.000
MI	0 (0.0)	0 (0.0)	NA
Repeat valve procedure	0 (0.0)	0 (0.0)	NA
CV rehospitalization	17 (4.8)	17 (4.8)	1.000
Non-CV rehospitalization	20 (5.7)	15 (4.3)	0.385
Any rehospitalization	36 (10.3)	30 (8.5)	0.437
Cumulative 30-d outcomes, n (%)			
Death	4 (1.1)	3 (0.9)	1.000
Any stroke	3 (0.9)	7 (2.0)	0.202
MI	0 (0.0)	1 (0.3)	1.000
Repeat valve procedure	2 (0.6)	0 (0.0)	0.499
CV rehospitalization	17 (4.8)	17 (4.8)	1.000
Non-CV rehospitalization	20 (5.7)	15 (4.3)	0.385
Any rehospitalization	36 (10.3)	30 (8.5)	0.437

CV indicates cardiovascular; MI, myocardial infarction; NA, not applicable; S3i, PARTNER SAPIEN-3 Intermediate Risk; SNF, skilled nursing facility; and TAVR, transcatheter aortic valve replacement.

In-Hospital Resource Use and Costs

Resource use and costs for the index TAVR procedure and the associated hospitalization are summarized in Table 3, Table S3, and Figure S3. By design, 3M-TAVR patients were less likely to receive general anesthesia than S3i patients (2% versus 87%). Procedure duration was shorter in the 3M-TAVR group compared with the S3i group with respect to skin-to-skin time (50 versus 77 minutes; $P<0.001$) as well as total room time (114 versus 181 minutes; $P<0.001$). Finally, both intensive care unit length of stay (1.1 versus 1.6 days) and non-intensive care unit length of stay (0.6 versus 2.3 days) were shorter in the 3M-TAVR cohort ($P<0.001$ for both). As a result, procedure-related costs were $1551 lower, nonprocedure hospitalization-related costs were $8193 lower, and physician fees were $675 lower in the 3M-TAVR cohort compared with the S3i cohort ($P<0.001$ for all). Total index hospitalization costs were $10 843 lower in the 3M-TAVR group compared with the S3i group ($45 595 versus $56 438, $P<0.001$).

Follow-Up Resource Use and Costs

Follow-up resource utilization and costs are summarized in Table 4, Table S4, and Figure S3. Between discharge and 30-day follow-up, the 3M-TAVR and S3i cohorts had a similar number of hospitalizations (0.12 versus 0.10 per patient) and hospital days (0.6 versus 0.4 per patient), while the number of rehabilitation/skilled nursing facility days was lower in the 3M-TAVR group (0.4 versus 1.4

Table 3. In-Hospital Resource Use and Costs

	3M-TAVR	S3i	Difference* (95% CI)†	*P* value
General anesthesia, %	1.4	88.0	−86.6 (81.4 to 89.0)	<0.001
Procedure duration				
Skin-to-skin time,‡ min	50.2±26.8	77.2±37.5	−27.0 (−31.8 to −22.2)	<0.001
Total room time,§ min	114.7±30.1	180.8±50.0	−66.1 (−72.2 to −60.0)	<0.001
Hospital length of stay				
ICU, d	1.1±2.1	1.6±1.7	−0.5 (−0.8 to −0.3)	<0.001
Non-ICU, d	0.6±1.3	2.3±2.7	−1.7 (−2 to −1.4)	<0.001
Total, d	1.6±2.3	3.9±3.3	−2.2 (−2.6 to −1.8)	<0.001
Risk-adjusted costs				
Index procedure, $	37 991±1596	39 542±2394	−1551 (−1859 to −1243)	<0.001
Hospitalization, $	5612±10 399	13 805±12 377	−8193 (−9769 to −6479)	<0.001
Physician fees, $	2573±634	3249±1228	−675 (−802 to −536)	<0.001
Total, $‖	45 595±6344	56 438±12 967	−10 843 (−12 314 to −9252)	<0.001

ICU indicates intensive care unit; S3i, PARTNER SAPIEN-3 Intermediate Risk; and TAVR, transcatheter aortic valve replacement.
*Absolute differences reported as 3M-TAVR minus S3i.
†95% CIs for cost differences and *P* values derived via bootstrapping.
‡Skin-to-skin time defined as the time between sheath insertion and vascular closure.
§Total room time defined as the difference in time between when the patient bed entered the room (at the beginning of the procedure) and when the patient bed left of the room (at the end of the procedure).
‖Total costs trimmed at 99th percentile for overall cost.

per patient; *P*<0.001). Mean follow-up costs were similar between the 2 groups ($3830 versus $4291; *P*=0.36). Cumulative 30-day costs including both the index hospitalization and follow-up period were $11 305/patient lower in the 3M-TAVR cohort compared with the S3i cohort ($49 425 versus $60 729; *P*<0.001)—driven mainly by the difference in index hospitalization costs (Figure; Table S5).

Sensitivity Analysis

In a sensitivity analysis using regression models to estimate costs instead of actual costs in the S3i cohort, we found similar results to the primary analysis with total index hospitalization costs $10 394 lower (*P*<0.001), total follow-up costs similar (*P*=0.914), and cumulative 30-day costs $10 321 lower (*P*<0.001) in the 3M-TAVR group relative to the S3i cohort (Tables S6 and S7).

DISCUSSION

In this propensity-matched analysis of the 3M-TAVR and S3i trials, we found that minimalist TAVR led to similar in-hospital and 30-day clinical outcomes as conventional TAVR and ≈$11 000 lower cumulative costs at 30 days. Cost savings with minimalist TAVR were driven mainly by shorter intensive care unit and non-intensive care unit length of stay during the index hospitalization with attendant reductions in nonprocedure related costs. Importantly, there were no differences in resource utilization or cost from hospital discharge to 30-day follow-up between the 2 groups. As such, the cost savings achieved during the index hospitalization were maintained at 30-day follow-up. Moreover, there was no increase in adverse events either during the index hospitalization or in follow-up as a result of implementing the simpler, streamlined 3M-TAVR protocol. These results strongly support use of the minimalist TAVR pathway and have implications for the cost-effectiveness and broader uptake of TAVR.

The extent of cost savings associated with minimalist TAVR in the 3M-TAVR trial is similar to that seen in previous economic analyses of minimalist TAVR—most of which have been single-center studies using a pre/post design. These previous studies have demonstrated cost savings ranging from $4000 to $16 000 per patient depending on which components of minimalist TAVR were incorporated in the care pathway.[6–8] Our study extends these previous studies by demonstrating that their single-center findings can be replicated across multiple hospitals spanning a wide range of annualized TAVR volumes. Our study is also the first to include 30-day follow-up costs, thus demonstrating that the minimalist pathway can produce true cost savings to the health care system rather than simply shifting costs from the inpatient to the outpatient setting.

The primary mechanism of cost savings in our study was a reduction of >$8000 in nonprocedure related costs during the index hospitalization, driven primarily by shorter length of stay. Importantly, both the 3M-TAVR and S3i study cohorts were enrolled largely between 2014 and 2016, a timeframe during which median length of stay after TAVR ranged from 3 to 6 days, while length of stay in contemporary practice is now 1 to 2 days—similar to that seen in 3M-TAVR.[10] Thus, it is likely that current practice already reflects many of the lessons provided by the 3M-TAVR experience, such that many of these gains have already been realized.[11]

Table 4. Follow-Up Resource Use and Costs (Through 30 Days)

	3M-TAVR	S3i	Difference (95% CI)*	*P* value
Resource use (count/patient)				
Total hospitalizations	0.12±0.38	0.10±0.33	0.023 (−0.03 to 0.08)	0.436
CV hospitalizations	0.06±0.28	0.05±0.22	0.01 (−0.03 to 0.05)	0.973
Non-CV hospitalizations	0.06±0.26	0.05±0.24	0.01 (−0.03 to 0.05)	0.393
Hospital days	0.6±3.2	0.4±1.7	0.2 (−0.2 to 0.6)	0.683
Rehabilitation/SNF, d	0.4±3.6	1.4±4.5	−0.9 (−1.6 to −0.3)	<0.001
Costs, $				
Total hospitalizations	1976±7395	1268±5101	708 (−220 to 1701)	0.142
CV hospitalizations	1088±6326	788±3875	300 (−412 to 1116)	0.476
Non-CV hospitalizations	888±3821	480±3096	408 (−109 to 893)	0.140
Rehabilitation/SNF stays	290±2286	1022±3674	−732 (−1139 to −274)	<0.001
Outpatient services	382±64	466±1057	−84 (−209 to 15)	0.132
Other†	820±448	925±1563	−105 (−265 to 54)	0.230
Physician fees	613±132	685±1212	−73 (−212 to 40)	0.246
Total follow-up cost‡				
Mean±SD	3830±6258	4291±6986	−462 (−1432 to 472)	0.358
Median	1784	1281		

CV indicates cardiovascular; S3i, PARTNER SAPIEN-3 Intermediate Risk; SNF, skilled nursing facility; and TAVR, transcatheter aortic valve replacement.

*95% CI for cost differences and *P* value derived via bootstrapping.

†Other costs include hospice and home health aide services.

‡Risk adjusted using propensity matching. Trimmed at 99th percentile for overall cost.

Nevertheless, next-day discharge represents an important step forward in the evolution of TAVR, particularly when considering that long lengths of stay (>7 days) remain common in many parts of the world.[12,13] More recently, in the setting of the COVID-19 pandemic, some US TAVR centers have explored same-day discharge in select patients,[14] although the broad applicability and economic implications of this strategy remain uncertain. Reduced procedure duration also contributed to lower costs with the 3M-TAVR pathway. Although it was not possible to determine the precise mechanisms underlying shorter procedure times, it is likely that multiple factors including elimination of general anesthesia, transesophageal echocardiography, and invasive hemodynamic monitoring were key contributors.

In addition to implications for the overall health care system, our findings have implications for hospitals' financial bottom line as well. Unlike many beneficial medical

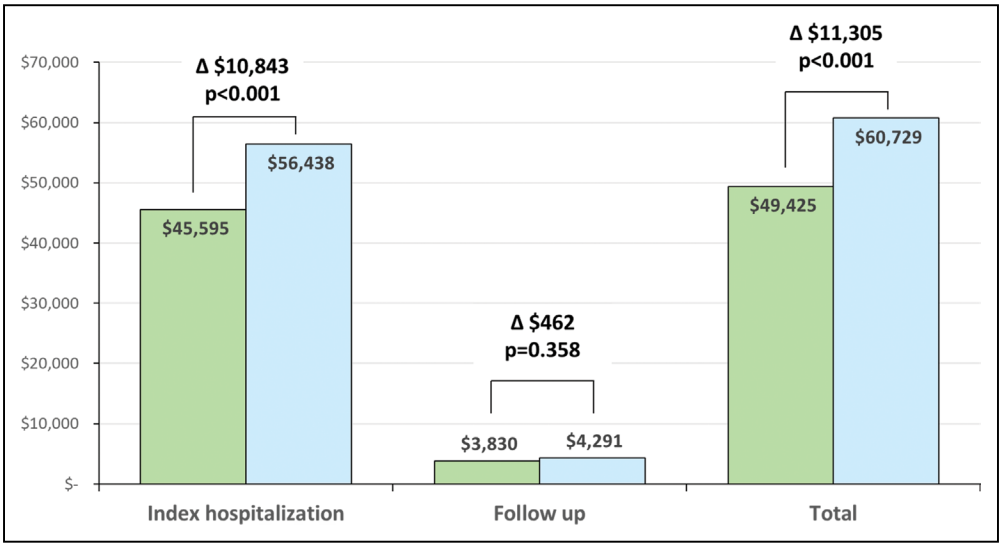

Figure. Mean costs and cost differences for the 3M-TAVR (3M-Transcatheter Aortic Valve Replacement) and S3i (PARTNER SAPIEN-3 Intermediate Risk) groups during the index hospitalization, 30-d follow-up period, and total study period.
Index hospitalization and follow-up costs were each trimmed at the 99th percentile before summation. 3M-TAVR=green and S3i=blue.

interventions that produce cost savings over the long-term, the cost savings of nearly $11 000/patient seen with minimalist TAVR occurred almost entirely during the index hospitalization with no cost penalty at 30-day follow-up. These cost savings thus accrue directly to the treating hospital (rather than a third-party payer), which should motivate substantial institutional investment to achieve these efficiencies. Moreover, by reducing length of stay, minimalist TAVR has the potential to free up hospital beds for additional patients, thus generating additional hospital revenue with little impact on variable costs.

From the health system perspective, the economic implications of minimalist TAVR may be even greater than suggested by our study. Previous studies have demonstrated that for patients at intermediate surgical risk (similar to those in the 3M-TAVR and S3i trials), conventional TAVR is associated with cost savings of ≈$9000 per patient compared with surgical aortic valve replacement.[3] When combined with the $11 000/patient cost savings seen with the 3M-TAVR pathway, these 2 studies suggest total cost savings in excess of $20 000 per patient with minimalist TAVR compared with surgical aortic valve replacement, further increasing the appeal of TAVR for the intermediate-risk population.

Limitations

Our results should be interpreted in light of several important limitations. First, as a nonrandomized study, our results may reflect unmeasured confounding not captured by our propensity score, such as differences in operator volume or hospital efficiency between 3M-TAVR and S3i sites. Nonetheless, given the similar time frames of the studies and the fact that the 3M-TAVR and S3i populations were quite similar before propensity matching, we think the extent of unmeasured confounding is likely minimal. Second, the results of this study may not apply to patients in low or high surgical risk subgroups, since the majority of patients included were at intermediate risk. Moreover, our findings may not apply to all intermediate-risk patients, since the 3M-TAVR trial excluded patients who may not have been suitable for next-day discharge for nonclinical reasons such as distance from the TAVR center or inadequate social support.

Third, given that only patients with balloon-expandable valves were included, these results may not be applicable to other devices—particularly if associated with increased rates of complications, such as heart block or bundle branch block, which may affect postprocedure LOS. Fourth, we cannot determine which components of the 3M-TAVR pathway were most important to achieving cost savings. Fifth, our study applied US-specific costs to 3M-TAVR patients, many of whom were treated in Canada. However, comparison of US versus Canadian sites in 3M-TAVR demonstrated no major differences in resource utilization, thus suggesting our approach should provide appropriate cost estimates for the US health care system (which was the analytic perspective of our study). Sixth, it is possible that physicians participating in 3M-TAVR, a trial that was designed to test resource-efficient care, may have approached patient management differently from those in the S3i trial, in which the emphasis was on gaining as much information as possible about a relatively new valve (S3i). For instance, it is possible that the small, nonsignificant difference in stroke rates may have stemmed from pursuit of minor neurological observations with more expansive neurological work-ups in S3i. And finally, as noted above, it is likely that many US hospitals—which currently achieve median lengths of stay of 1 to 2 days after TAVR—are already practicing much of the 3M pathway and have already realized these savings.

Conclusions

The minimalist TAVR pathway used in the 3M-TAVR trial was associated with cost savings of >$11 000 per patient compared with conventional TAVR without evidence of increased adverse clinical sequelae in a contemporary intermediate-risk cohort. These findings suggest that continued emphasis on a minimalist approach to TAVR is likely to provide substantial benefits to patients, hospitals, and the health care system.

ARTICLE INFORMATION

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Supplemental Material

Figures S1–S3
Tables S1–S7

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