Transcarotid Versus Transfemoral Transcatheter Aortic Valve Replacement (from a Propensity-Matched Comparison)

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Previous reports comparing transcarotid (TC) versus transfemoral (TF) approaches for patients undergoing transcatheter aortic valve replacement have had inconsistent conclusions. We compared in-hospital and 1-year clinical outcomes, changes in quality of life, and direct hospital costs for 138 TC versus 1,926 TF procedures. Propensity matching based on the Society of Thoracic Surgery Predicted Risk of Mortality was used to compare 130 patients who underwent TC with 813 patients who underwent TF. Matched TC versus TF cohorts did not differ with respect to in-hospital mortality (0.0% vs 1.4%, p = 0.380), stroke (2.3% vs 2.5%, p = 0.917), major vascular complications (0.8% vs 2.2%, p = 0.268), composite bleeding complications (4.6% vs 6.4%, p = 0.647), requirement for permanent pacemaker (14.6% vs 12.9%, p = 0.426), postoperative hospital length of stay (3.3 ± 3.4 vs 3.1 ± 3.3 days, p = 0.467), or direct hospital costs ($52,899 ± 9,560 vs $50,464 ± 10,997, p = 0.230). Similarly, at 1-year, patients who underwent TC versus patients who underwent TF did not differ with respect to all-cause mortality (7.6% vs 6.4%, p = 0.659), hospital readmission (20.0% vs 23.9%, p = 0.635), or quality of life as measured by the Kansas City Cardiomyopathy Questionnaire score (84.0 ± 17.1 vs 88.4 ± 13.9, p = 0.062). Patients who underwent TC and TF did not differ with respect to in-hospital complications, length of hospital stay, and direct hospital costs, as well as 1-year mortality, readmission, and quality of life. These data add to ongoing support for the TC approach as the optimal alternative access for patients with transcatheter aortic valve replacement deferred from a transfemoral approach. **(Am J Cardiol 2022;185:71−79)**

Introduction

Despite the availability of lower profile vascular sheaths and valve delivery systems for transcatheter aortic valve replacement (TAVR), approximately 5% to 15% of patients with TAVR currently require alternative vascular access because of unsuitable iliofemoral anatomy that prevents the use of the conventional transfemoral (TF) approach.[1] Alternative TAVR access routes that have been described over the last 2 decades include the transapical, direct aortic, transcaval, subclavian/axillary (TAx), and transcarotid (TC) approaches. Although each of these strategies may be suitable for a given patient based on anatomic constraints, there has been a gradual evolution in the use of different alternative access techniques.

As the first alternative access strategy that was used, transapical access has been progressively abandoned due to its invasiveness and consistent reports of increased mortality and morbidity, including increased stroke rates.[2−5] A direct aortic approach was used in the landmark high- and intermediate-risk TAVR trials,[6−8] but this strategy has likewise been supplanted by the TAx approach as the most common, currently-used alternative access route in the United States according to recent data from the Society of Thoracic Surgeons/American College of Cardiology Transcatheter Valve Therapy (STS/ACC TVT) registry.[9] Notably, previous studies have demonstrated decreased mortality and shorter intensive care unit and hospital length of stay with the TAx approach compared with the transapical and direct aortic approaches.[9,10]

First introduced in 2010, the TC TAVR approach has recently emerged as a possible alternative to the TAx technique.[11] Previous studies have demonstrated that the TC approach has higher success rates and fewer complications than the transapical and direct aortic strategies.[12−14] Additional reports have demonstrated decreased stroke rates with TC versus TAx approaches.[15] Despite these reports, TC TAVR has not gained widespread acceptance across the

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United States and only represented 0.9% of all cases performed in 2019.[16]

In the absence of randomized trials, current attempts to identify the optimal TAVR alternative access approach have focused on comparisons with the transfemoral approach as the default access strategy. Previous retrospective studies comparing TC with TF approaches have been limited and have demonstrated inconsistent results. In a 2021 meta-analysis examining outcomes in 1,374 patients who underwent TC and 3,706 patients who underwent TF, the TC cohort had a higher risk of 30-day mortality and neurovascular complications.[17] In contrast, other studies have documented similar mortality and stroke risks for the 2 approaches at 30 days[18−21] and at 1-year follow-up.[22,23]

Given the contrasting results of previous reports, the aim of the present study was to compare TC versus TF approaches in a large-volume TAVR center, with respect to in-hospital and 1-year clinical outcomes, changes in quality of life, and direct hospital costs for the index TAVR procedure.

Methods

This retrospective, observational study was conducted at Hartford Hospital, an 890-bed tertiary-care urban medical center in Hartford, Connecticut. The Hartford Hospital Institutional Review Board approved the study and certified that it met the criteria for a waiver of the requirement to obtain written informed consent.

From a total cohort of 2,162 TAVR procedures performed at our institution since 2016, we compared in-hospital and 1-year clinical outcomes in 138 patients who underwent TC versus 1,926 patients who underwent TF, treated with current-generation balloon-expandable (SAPIEN 3 [Ultra]; Edwards Lifesciences, Irvine, California) or self-expandable (Evolut R, Evolut Pro, Evolut Pro Plus; Medtronic Inc., Minneapolis, Minnesota) transcatheter heart valves. All patients underwent a standardized pre-TAVR evaluation by a multidisciplinary valve team to ensure that patients met the criteria for severe aortic stenosis; to review preprocedure echocardiographic, cardiac catheterization, carotid duplex, and computed tomography angiography (CTA) findings (e.g., chest, abdomen, pelvis); and to assess the preprocedure Society of Thoracic Surgery Predicted Risk of Mortality score (STS PROM).

Access site selection was made by the multidisciplinary valve team after a review of carotid duplex and CTA data. Patients were considered for the TC approach if they had unfavorable femoral access either because of inadequate size of the iliofemoral arteries, presence of lower extremity prosthetic grafts, presence of extensive calcification or severe aortoiliac tortuosity, evidence of a hostile groin with infection or rash, or morbid obesity with a body mass index >40 kg/m^2. In addition, patients were considered for the TC approach if they had a left or right common carotid artery diameter of more than 5.5 mm; no evidence of common carotid artery calcification, tortuosity, or stenosis along the whole length of the artery; and no stenosis >79% in the ipsilateral and contralateral internal carotid arteries. Head CTA data were not used in the decision process for assigning a TC approach and was not routinely acquired for pre-TAVR screening.

The TC and TF cohorts were compared regarding baseline demographic data, cardiovascular risk factors, co-morbidities, previous cardiac history, preoperative cardiac catheterization, echocardiographic and CTA results, STS PROM, Kansas City Cardiomyopathy Questionnaire (KCCQ12) score, and procedural details. In addition, the 2 cohorts were compared for procedural complications, in-hospital mortality, in-hospital stroke and transient ischemic attack, major and minor vasculature complications, composite bleeding complication, need for new dialysis, need for permanent pacemaker implantation, and hospital length of stay. Composite bleeding was defined as a combination of access site bleeding, hematoma at the access site, retroperitoneal bleeding, gastrointestinal bleeding, and genitourinary bleeding. All analyzed data were obtained from an institutional TAVR database, prospectively maintained by the hospital's Cardiovascular Quality Department and queries from the institutional electronic medical record database (EPIC; Epic System Corp, Verona, Wisconsin). All data elements were defined according to the STS/ACC TVT registry, and all adverse outcomes reported were in accordance with the Valve Academic Research Consortium definitions.[24]

All procedures were performed in a hybrid operating suite by a structural heart team, led by 1 of 2 cardiothoracic surgeons and an interventional cardiologist. Standard techniques for implantation of balloon-expandable and self-expandable valves were used. A temporary pacemaker was implanted either by a jugular or femoral vein access, and radial or femoral arterial access was used for pigtail guidance. TF cases were performed using either conscious sedation or general anesthesia, whereas general anesthesia was used in all but 3 TC procedures. All patients underwent invasive hemodynamic monitoring with transthoracic or transesophageal guidance. Unfractionated intravenous heparin was administered to achieve an activated clotting time of at least 250 seconds. All TC cases were performed with neuromonitoring, including electroencephalography and somatosensory evoked potential.

For the TC surgical technique, surgical cutdown of common carotid artery was performed medial to the sternocleidomastoid muscle in the lower neck using a small longitudinal incision. The vessel was circumferentially dissected to avoid cranial nerve injury and atraumatic handling of the artery during large-bore sheath insertion. Once isolated, arterial access was obtained using the modified Seldinger technique, with an 18-gauge needle. The sheaths were carefully inserted with the index finger behind the artery to guide large-bore sheaths into the arch. The sheath was fixated manually by a dedicated assistant to avoid trauma from inadvertent pulling or pushing of sheath during valve insertion. Care was undertaken to flush the sheaths without introducing any air or embolic debris. After valve delivery, the vessels were surgically clamped and repaired with interrupted Prolene sutures. Intraoperative duplex ultrasound or selective carotid angiography was performed to ensure no injury to the vessel before closure of the wound.

The TC and TF cohorts were compared for direct hospital costs for the index TAVR procedure, including total costs, and costs related to hybrid operating room use, medical and surgical supplies, room and board, pharmacy, laboratory testing, diagnostic imaging, blood product utilization, rehabilitative services, and miscellaneous ancillary charges. Cost data were obtained from the hospital's Finance Department for unmatched patients treated over a 12-month period from October 1, 2020 to September 30, 2021.

Clinical follow-up was assessed in all patients based on the analysis of postdischarge visits recorded in the electronic medical record and by telephone interviews with the patient or referring physician. The TC and TF matched cohorts were compared with respect to 1-year all-cause mortality, quality of life as measured by KCCQ12 score, and hospital readmission.

Continuous variables are expressed as mean ± SD or median (interquartile range) and were compared using a *t* test or the Mann-Whitney *U* test, respectively. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate. The Kruskal-Wallis test was used to compare 3 or more groups. Bonferroni corrections were used for multiple comparisons.

Differences between TC and TF groups limited the direct comparison of the patients. To compensate for these differences, propensity score-matched groups were created through matching the STS PROM score. Patients were matched 1: 7 using the greedy nearest-neighbor algorithm, with a maximum caliper width of 0.05. The quality of the matching was determined by assessing whether any variable or linear combination of variables were significantly unbalanced after matching using the model imbalance chi-square test. Overall mode performance was measured using Nagelkerke R^2, a measure of explained variance, and the Hosmer-Lemeshow test.

All effects were considered significant at $p < 0.05$. The statistical analyses were performed with SPSS 21.0 (SPSS, Chicago, Illinois). Propensity score matching was performed using Propensity Score Matching for SPSS, version 3.0.4.

Results

After the propensity matching of 138 TC versus 1,926 TF procedures, the 2 cohorts were well matched except for body surface area, hypertension, smoking history, peripheral arterial disease, chronic obstructive lung disease, and previous carotid artery surgery. Baseline clinical characteristics and pre-TAVR testing results are listed in Tables 1 and 2, respectively, for unmatched and matched groups.

General anesthesia was used in 97.7% and 26.4% of TC and TF procedures, respectively. There were no cohort differences with respect to the use of balloon-expandable and self-expandable valves. Procedure duration was higher in the TC group, although patients who underwent TC required a lower use of contrast. Fluoroscopy time was similar for patients who underwent TC and TF, with a similar dose area product and a lower TC Air Kerma (Table 3).

There were no differences between the 2 cohorts with respect to intraprocedural adverse events (e.g., conversion to open-heart surgery, cardiac arrest, annular rupture, aortic dissection, coronary obstruction, ventricular perforation). In addition, the 2 groups did not differ with respect to in-

Table 1
Baseline demographics, cardiovascular risk factors, co-morbidities and prior cardiac history for unmatched and matched groups

		Unmatched			Matched		
		TCn = 138	TFn = 1,926	p Value	TCn = 130	TFn = 813	p Value
Demographics	Age (years)	80.7 ± 7.5	81.3 ± 8.4	0.399	81.0 ± 7.5	82.4 ± 8.1	0.059
	Female Gender	67 (48.6)	886 (46.0)	0.562	63 (48.5)	404 (49.7)	0.794
	BSA (m^2)	1.92 ± 0.32	1.90 ± 0.27	0.361	1.93 ± 0.32	1.86 ± 0.27	**0.038**
	BMI (kg/m^2)	29.66 ± 8.98	29.45 ± 17.92	0.893	29.6 ± 9.1	28.7 ± 17.6	0.572
	Race (White)	132 (95.7)	1, 862 (96.7)	0.521	124 (95.4)	784 (96.4)	0.557
STS PROM		12.80 ± 7.54	9.15 ± 7.33	**<0.001**	12.37 ± 6.90	11.20 ± 7.06	0.072
Cardiovascular Risk Factors	AODM	55 (39.9)	622 (32.3)	0.068	52 (40.0)	276 (34.0)	0.179
	Hypertension	135 (97.8)	1,717 (89.1)	**0.001**	127 (97.7)	739 (90.9)	**0.009**
	Prior/Current Smoking	45 (32.6)	252 (13.1)	**<0.001**	41 (31.5)	93 (11.4)	**<0.001**
Co-morbidities	COPD	89 (64.5)	764 (39.7)	**<0.001**	82 (63.1)	371 (45.6)	**0.001**
	Prior CVA	11 (8.0)	187 (9.7)	0.503	11 (8.5)	88 (10.8)	0.415
	Prior TIA	10 (7.2)	122 (6.3)	0.672	9 (6.9)	55 (6.8)	0.947
	PVD	80 (58.0)	312 (16.2)	**<0.001**	74 (56.9)	153 (18.8)	**<0.001**
	Atrial Fibrillation	51 (37.0)	729 (37.8)	0.452	48 (36.9)	356 (43.8)	0.217
	Dialysis	4 (2.9)	46 (2.4)	0.707	4 (3.1)	29 (3.6)	0.778
Prior Cardiac History	Prior MI	49 (35.5)	396 (20.6)	**<0.001**	46 (35.4)	180 (22.1)	**0.001**
	Prior PCI	42 (30.4)	482 (25.0)	0.158	42 (32.3)	201 (24.7)	0.066
	Prior CABG	36 (26.1)	307 (15.9)	**0.002**	32 (24.6)	154 (18.9)	0.131
	Prior SAVR	4 (2.9)	108 (5.6)	0.175	4 (3.1)	45 (5.5)	0.241
	Prior CAS	40 (29.0)	201 (10.4)	**<0.001**	37 (28.5)	89 (10.9)	**<0.001**

AODM = adult onset diabetes; BMI = body mass index; BSA = body surface area; CABG = coronary artery bypass grafting; CAS = carotid artery surgery; COPD = chronic obstructive lung disease; CVA = cerebrovascular accident; MI = myocardial infarction; PCI = percutaneous coronary intervention; PVD = peripheral vascular disease; SAVR = surgical aortic valve replacement; STS = Society of Thoracic Surgeons; TC = transcarotid; TF = transfemoral; TIA = transient ischemic attack.

Values are expressed as n (%) or mean±standard deviation.

Table 2
Baseline echocardiographic, cardiac catheterization, CTA and KCCQ12 measurements for unmatched and matched groups

		Unmatched			Matched		
		TCn = 138	TFn = 1926	p Value	TCn = 130	TFn = 813	p Value
Echocardiography	AV Mean Gradient (mmHg)	40.5 ± 13.7	41.7 ± 14.3	0.317	40.2 ± 13.5	40.7 ± 14.4	0.726
	AV Peak Velocity (m/sec)	4.1 ± 0.7	4.1 ± 0.7	0.684	4.0 ± 0.7	4.0 ± 0.7	0.990
	AV Area (cm^2)	0.7 ± 0.2	0.7 ± 0.2	0.680	0.7 ± 0.2	0.7 ± 0.3	0.422
	LV EF (%)	56.7 ± 12.8	56.3 ± 13.4	0.761	56.8 ± 13.0	54.7 ± 14.4	0.117
Cardiac Catheterization	No CAD	42 (30.4)	474 (24.6)	0.234	41 (31.5)	194 (23.9)	0.313
	1 Vessel Disease	24 (17.4)	290 (15.1)		20 (15.4)	133 (16.4)	
	2 Vessel Disease	22 (15.9)	290 (15,1)		20 (15.4)	147 (18.1)	
	3 Vessel Disease	50 (36.2)	872 (45.3)		49 (37.7)	339 (41.7)	
	Peak AV Gradient (mmHg)	68.2 ± 22.1	68.6 ± 22.7	0.863	67.9 ± 22.2	67.6 ± 23.9	0.924
CTA	AV Annulus Size (mm)	23.6 ± 3.0	23.4 ± 3.1	0.374	23.7 ± 3.0	23.4 ± 3.0	0.335
Quality of Life	KCCQ12 Score	48.9 ± 26.7	49.5 ± 25.3	0.787	48.3 ± 26.7	45.9 ± 25.3	0.331

AV = aortic valve; CAD = coronary artery disease; CTA = computed tomography angiography; EF = ejection fraction; KCCQ12 = Kansas City Cardiomyopathy Questionnaire; LV = left ventricle; TC = transcarotid; TF = transfemoral VD = vessel disease.

Values are expressed n (%) or mean ± standard deviation.

hospital mortality, transient ischemic attack or stroke, major or minor vascular complications, composite bleeding complications, renal failure requiring dialysis, need for permanent pacemaker implantation, or total and postoperative hospital length of stay (Table 4).

The TC versus TF cohorts did not differ with respect to 1-year mortality (7.6% vs 6.4%, p = 0.659) or need for hospital readmission (20.0% vs 23.9%, p = 0.635). Figure 1 demonstrates no significant difference in survival curves for the 2 groups. The KCC12 scores, which were not significant before TAVR, remained similar at 1-year follow-up. Figure 2 demonstrates improvement in KCCQ12 scores for both groups.

As illustrated in Figure 3, total direct costs for the index TAVR procedure were equivalent for TC versus TF cohort ($52,899 ± 9,560 vs $50,464 ± 10,997, p = 0.230). Although patients who underwent TC had higher operating room, room and board, pharmacy, diagnostic imaging, laboratory testing, and other postoperative ancillary charges, these costs were offset by increased charges for medical and surgical supplies in the TF cohort. These increased TF supply costs are primarily related to the use of increased percutaneous vascular closure devices used to close the instrumented femoral artery.

Discussion

The results of this study add to previous reports documenting the safety and efficacy of the TC approach in treating a high-risk cohort of patients with TAVR with a high burden of cardiovascular disease and associated co-morbidities. Notably, in a propensity-matched comparison with the least invasive, gold-standard TF approach, patients who underwent TC and TF did not differ with respect to procedural and in-hospital complications, length of hospital stay, direct hospital costs, and 1-year clinical outcomes, including all-cause mortality, need for hospital readmission, and changes in quality of life.

Table 3
Procedural characteristics for unmatched and matched groups

		Unmatched			Matched		
		TCn = 138	TFn = 1,926	p Value	TCn = 130	TFn = 813	p Value
Anesthesia Type	General Anesthesia	135 (97.8)	421 (21.9)	**<0.001**	127 (97.7)	215 (26.4)	**<0.001**
	Moderate Sedation	3 (2.2)	1,505 (78.1)		3 (2.3)	598 (73.6)	
Device Type	Sapien 3 (Ultra)	94 (68.1)	1,204 (62.5)	0.304	87 (66.9)	526 (64.7)	0.138
	Evolut R	12 (8.7)	259 (13.4)		11 (8.5)	96 (11.8)	
	Evolut Pro	15 (10.9)	181 (9.4)		15 (11.5)	72 (8.9)	
	Evolut Pro Plus	17 (12.3)	282 (14.8)		17 (13.1)	119 (14.5)	
Contrast Volume (ml)		77.1 ± 42.1	91.1 ± 57.2	**0.005**	77.81 ± 42.9	88.9 ± 53.6	**0.025**
Procedure Duration (hrs)		1.9 ± 1.1	1.5 ± 0.8	**<0.001**	1.9 ± 1.1	1.5 ± 0.8	**<0.001**
Fluoroscopy Time (mins)		19.6 ± 7.6	20.0 ± 13.6	0.732	19.6 ± 7.8	20.6 ± 12.8	0.397
DAP (Gy*cm^2)		77,703 ± 92,204	123,381 ± 82,524	0.325	77,710 ± 92,900	121,641 ± 333,088	0.222
Air Kerma (mGy)		661.33 ± 614.9	846.8 ± 934.1	**0.022**	643.3 ± 591.7	897.1 ± 1,030	**0.007**

DAP = dose area product; TC = transcarotid; TF = transfemoral.

Values are expressed n (%) or mean±standard deviation.

Table 4
Procedural and in-hospital outcomes

		Unmatched			Matched		
		TCn = 138	TFn = 1,926	p Value	TCn = 130	TFn = 813	p Value
Procedural Complications	Conversion to Open-Heart Surgery	2 (1.5)	13 (0.7)	0.301	2 (1.5)	6 (0.7)	0.356
	Cardiac Arrest	0 (0.0)	23 (1.2)	0.192	0 (0.0)	12 (1.5)	0.160
	Annular Rupture	0 (0.0)	5 (0.3)	0.587	0 (0.0)	3 (0.4)	0.534
	Aortic Dissection	0 (0.0)	3 (0.2)	0.640	0 (0.0)	2 (0.2)	0.568
	Coronary Obstruction	0 (0.0)	3 (0.2)	0.677	0 (0.0)	1 (0.1)	0.722
	Ventricular Perforation	1 (0.7)	22 (1.1)	0.638	1 (0.8)	11 (1.4)	0.569
	Atrial Fibrillation	0 (0.0)	16 (0.8)	0.278	0 (0.0)	7 (0.9)	0.284
In-Hospital Outcomes	Mortality	0 (0.0)	20 (1.0)	0.281	0 (0.0)	11 (1.4)	0.380
	CVA	4 (2.9)	41 (2.1)	0.539	3 (2.3)	20 (2.5)	0.917
	TIA	1 (0.7)	9 (0.5)	0.525	1 (0.8)	3 (0.4)	0.380
	Major Vascular Complications	1 (0.7)	31 (1.6)	0.405	1 (0.8)	18 (2.2)	0.268
	Minor Vascular Complications	8 (5.8)	77 (4.0)	0.330	7 (5.4)	31 (3.8)	0.422
	Composite Bleeding Complications	6 (4.3)	101 (5.2)	0.646	6 (4.6)	44 (5.4)	0.647
	Permanent Pacemaker	20 (14.5)	235 (12.2)	0.481	19 (14.6)	105 (12.9)	0.426
	Renal Failure Requiring Dialysis	0 (0.0)	2 (0.1)	0.734	0 (0.0)	0 (0.0)	-
Length of hospital stay (days)	Total	5.2 ± 5.9	4.6 ± 5.7	0.220	5.3 ± 5.9	5.4 ± 5.9	0.836
	Postoperative	3.3 ± 3.3	2.8 ± 3.1	0.060	3.3 ± 3.4	3.1 ± 3.3	0.461

CVA = cerebrovascular accident; TC = transcarotid; TF = transfemoral; TIA = transient ischemic attack.
Values are expressed as n (%) or mean±standard deviation.

Because patients who underwent TC typically have contraindications to a TF approach, randomized control studies comparing the 2 access routes cannot be performed. As a result, previous comparisons between TC and TF strategies have been limited to single-center studies and meta-analyses of published results. To date, there have been 7 previous reports from 2021 to 2022, comparing TC and TF procedures with differing conclusions.

In a meta-analysis by Lu et al[17] comparing 1,374 TC and 3,706 TF procedures from 9 studies, the TC approach was associated with a lower incidence of major vascular complications but with a significantly higher risk of 30-day mortality and neurovascular complications. In contrast, a second meta-analysis by McGrath et al[18] comparing 611 patients who underwent TC and 1,859 patients who underwent TF from 5 studies demonstrated a similar reduction in TC vascular complications with nonsignificant differences in 30-day mortality and stroke. Smaller single-center studies have similar demonstrated nonsignificant 30-day[19−21] and 1-year[22,23] outcomes.

Patients undergoing TC TAVR typically have a higher disease burden, with a higher predicted STS surgical risk. As such, propensity matching is usually required to remove confounding variables to evaluate relative mortality risk. In this regard, the 1 metanalysis cited previously that demonstrated an increased 30-day mortality for TC versus TF procedures consisted of a mixture of 7 unmatched and 2 matched studies. In a subgroup pooled analysis of the 2 propensity score-matched reports, the TC and TF 30-day mortality were not statistically different.[17]

The present study demonstrates no differences between TC and TF cohorts with respect to 1-year clinical outcomes,

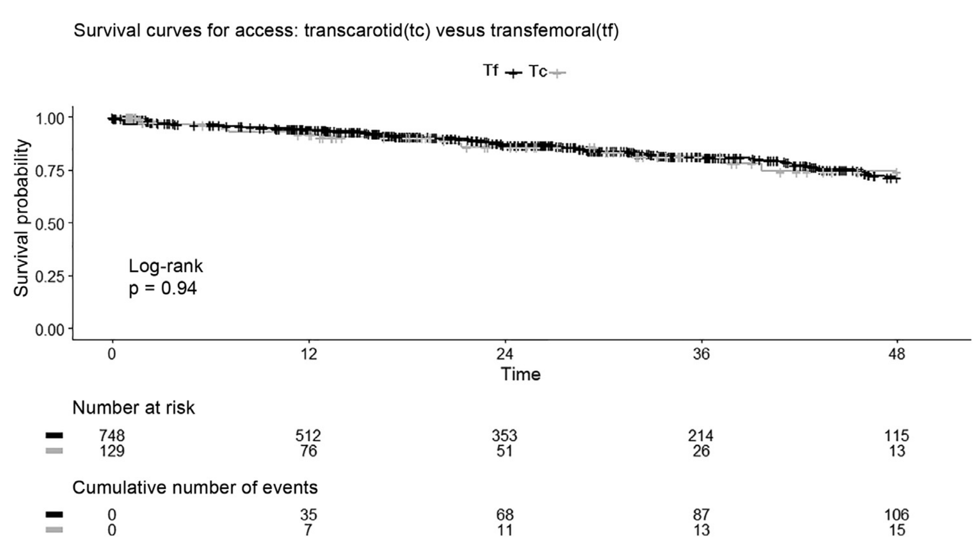

Figure 1. Kaplan-Meier estimate of survival after propensity score matching.

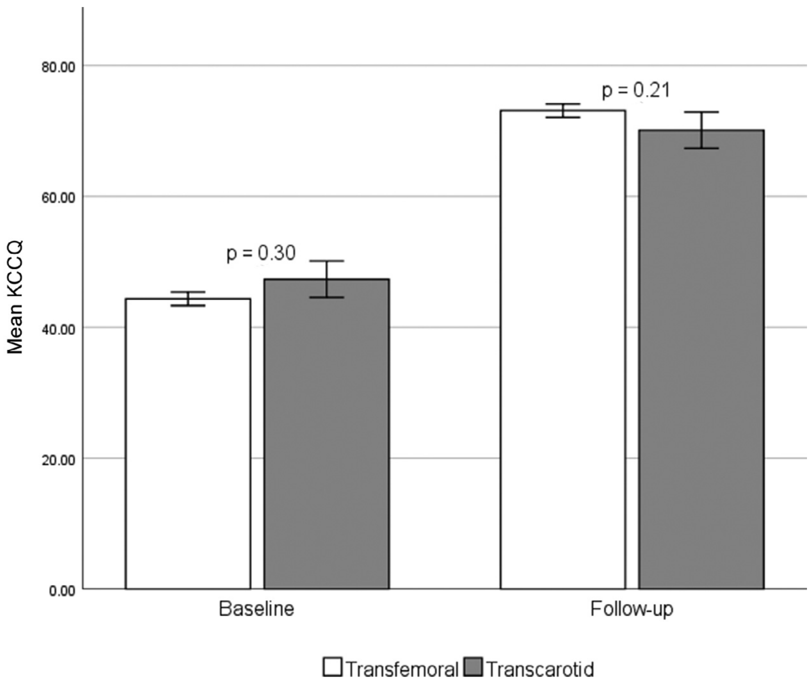

Figure 2. Baseline and 1-year KCCQ12 for transcarotid and transfemoral groups.

including all-cause mortality, hospital readmission, and changes in the KCCQ12 scores. These results are in agreement with a recent study by Jones et al[22] that compared 146 patients who underwent TC with 1,319 patients who underwent TF and reported unadjusted 1-year mortalities of 87% and 90% for the TC and TF subgroups, respectively. Similarly, in a 2022 analysis by Junquera et al[23] comparing 127 patients who underwent TC with 399 patients who underwent TF, no differences were found among groups regarding survival or neurologic events at 12-month follow-up. The present study adds to these reports using propensity-matched scoring and provides additional data on relative changes in the quality of life.

Despite longer TC procedure times, higher use of general anesthesia and the use of surgical cutdown requiring an intensive care unit admission, the present study reports similar total direct costs for patients who underwent TC and TF. Increased operating room costs and other postoperative

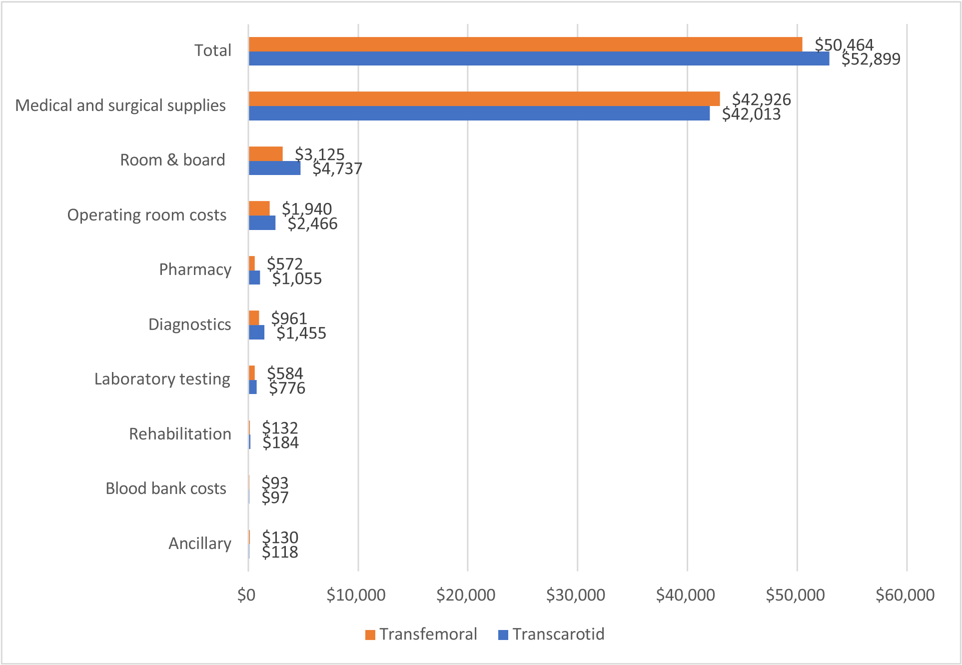

Figure 3. Breakdown of direct costs for transcarotid and transfemoral patients.

ancillary charges for the TC cohort were offset by increased TF medical and surgical supply costs, primarily related to increased use of percutaneous vascular closure devices.

Although the evolution of alternative access strategies has resulted in a transition away from transthoracic procedures (e.g., transapical, direct aortic) to less invasive extrathoracic techniques (e.g., TAx, TC, transcaval), there is ongoing debate over the relative merits and disadvantages of the individual extrathoracic approaches. After early reports that TAx outcomes were superior to transapical and direct aortic results[9,10] and comparable to the TF technique,[25] many centers have designated TAx as the preferred alternative access strategy. As a result, TAx use has accelerated in the United States and represented over 50% of alternative access cases performed in 2019.[16] In the absence of randomized trials, the possible designation of the TC approach as the consensus alternative to TF TAVR requires comparisons not only between TC and TF approaches but also between TC and TAx strategies.

Recent reports from the STS/ACC TVT registry have demonstrated a progressive decline in in-hospital and 30-day mortality from 2012 to 2019 for all TAVR procedures.[16] For TF TAVR, a similar decrease has been observed, with 2019 in-hospital and 30-day mortalities averaging 1.5% and 2.2%, respectively.[26]

Previous meta-analyses comparing TF and alternative access approaches have consistently demonstrated increased mortality with transapical and direct aortic approaches but no significance difference with the TAx and TC routes.[27,28] Similarly, no mortality differences have been documented in reports specifically comparing the TAx and TC approaches.[15,29]

A large 2020 metanalysis demonstrated an increased incidence of stroke for combined TC and TAx cohorts compared with patients who underwent TF.[27] The relative stroke risk for TC versus TAx approaches, however, remains controversial. Kirker recently published STS/ACC TVT propensity-matched registry data that showed similar 30-day mortality for the 2 approaches, with a statistically significant lower 30-day stroke risk for the TC cohort.[15] In contrast, a 2021 meta-analysis of 4,164 patients from 5 studies demonstrated no difference in stroke rates between the 2 access strategies.[29] Although the etiology of stroke in patients with TAVR is multifactorial and possibly decreased with the use cerebral embolic protection symptom, TAx stroke risk may be primarily related to the presence of a dominant vertebral artery at risk for occlusion, ischemia, and embolization during sheath insertion. Alternatively, stroke prevention with TC approach may be afforded by embolic protection related to ipsilateral sheath and/or carotid artery cross-clamping during the procedure. In addition, the TC's shorter and more direct angle of approach to the aortic annulus may require less catheter manipulation within the ascending aorta, with less embolic phenomenon.

A total of 3 previous meta-analyses cited previously have demonstrated a decrease in vascular complications for patients who underwent TC versus those who underwent TF.[17,18,28] In part, this observation may be related to the superficial location of the common carotid arteries, facilitating access and repair under direct visualization, compared with current results for ultrasound-guided percutaneous femoral access with the use of vascular closure devices.

A previous study comparing vascular and bleeding complications for TAx versus TF approaches demonstrated a higher major vasculature complication and major bleeding rate for the TAx technique,[30] but subsequent meta-analyses have demonstrated nonsignificant differences.[28] Of note, a previous report study by Gleason described potential difficulties with the TAx approach related to the fact that the subclavian artery is frequently positioned posterior to the subclavian or axillary vein and frequently surrounded by major brachial plexus and nerves.[25] This position relative to the axillary vein and brachial plexus may increase the risk of vascular and neurologic injury, particularly if off-label percutaneous access is attempted.

Several studies have demonstrated shorter procedure times, less contrast use, and less radiation exposure with the TC than the TAx approach, suggesting that TC TAVR may be technically simpler.[15,29] This may be related to ease of surgical cutdown and repair of the more superficially located common carotid artery compared with the subclavian artery, especially in patients who are obese. In addition, the decreased use of fluoroscopy in the TC compared with the TAx procedure is likely related to the shorter and straighter distance between the vascular access site and the aortic annulus, requiring less visualization of the valve under fluoroscopy during access obtainment and valve positioning.

This study is inherently limited by its retrospective nature, single-center experience, inability to perform randomization, and the relatively small sample size of the TC cohort. In addition, the recent emergence of intravascular lithotripsy to facilitate TF access potentially represents a disruptive technology that must be considered along with TC and TAx approaches in determining the optimal TAVR alternative access strategy.

The optimal alternative access for patients with TAVR deferred from the traditional TF approach is dependent on the individual patient's anatomic constraints and the previous experience of the surgical team. Although TAx currently remains as the most commonly used alternative access technique, this single-center retrospective analysis documenting similar in-hospital and 1-year outcomes between patients who underwent TC and patients who underwent TF adds to previous reports suggesting that a TC strategy may be considered as the first alternative in patients with contraindications to the femoral route. Additional studies, including randomized comparisons between TC and TAx approaches, as well as randomized comparisons with intravascular lithotripsy-facilitated TF TAVR, may be warranted before the consensus alternative to TF TAVR is established.

Disclosures

The authors have no conflicts of interest to declare.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2022.09.003.

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