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ORIGINAL ARTICLE

Trans-subclavian aortic valve replacement with various bioprosthetic valves: Single-center experience

Çeşitli biyoprotez kapaklarla yapılan subklaviyan yoluyla aort kapak yerleştirme: Tek merkez deneyimi

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ABSTRACT

Objective: Transcatheter aortic valve replacement (TAVR) has been accepted as an alternative to surgery in high risk or inoperable patients with severe aortic stenosis (AS). Although transfemoral approach is the most often preferred means of access, in patients with severe ilio-femoral arteriopathy, other vascular access sites may be required. The aim of the present study was to report our experience with trans-subclavian approach for TAVR using different valve systems.

Methods: Among 273 patients undergoing TAVR between June 2011 and May 2016, 10 patients (mean age: 68.3±7.6 years; 6 males) with high surgical risk were excluded from transfemoral TAVR because of ilio-femoral arteriopathy. Under general anesthesia, 9 of these patients underwent TAVR via left subclavian artery (SCA) and 1 patient via right SCA. Surgical cut-down and closure techniques were utilized in all patients. Eight balloon-expandable Edwards Sapien XT valves (size: one 23 mm, six 26 mm, and one 29 mm) were used, 1 patient received 26 mm balloon-expandable Sapien 3 valve, and 1 patient had 27 mm self-expandable Lotus valve implanted.

Results: Procedural success rate was 90%. Mean aortic gradient decreased to 10.6 mmHg from 47.4 mmHg. Emergent surgery was required in 1 patient due to complication of ventricular valve embolization. Thrombus formation at right SCA was detected in 1 patient and resolved with medical therapy. In-hospital mortality was not observed in any patients.

Conclusion: Trans-subclavian approach for TAVR is safe and feasible. Proper patient and valve selection concurrent with utilization of multimodal imaging techniques are crucial for successful and uncomplicated procedure.

ÖZET

Amaç: Transkatater aort kapak yerleştirme (TAKY) yüksek riskli ve ameliyat edilemeyen ciddi aort darlığı (AD) bulunan hastalarda cerrahiye seçenek bir tedavi şekli olarak kabul görmüştür. Günümüzde femoral yol en çok tercih edilen giriş yeri olsa da ciddi iliyofemoral arter hastalığı olanlarda diğer damar giriş yerlerini kullanmak gerekebilir. Bu yazıda, çeşitli kapak sistemleri kullanılarak yapılan subklaviyan yoluyla TAKY deneyimimizi paylaşmak istedik.

Yöntemler: Haziran 2011 ve Mayıs 2016 tarihleri arasında TAKY yapılan 273 hasta arasından, yüksek cerrahi riske sahip 10 hastaya (ortalama yaş: 68.3±7.6 yıl, 6 erkek) iliyofemoral arter hastalığı olduğu için femoral yoldan aort kapak yerleştirme yapılamadı. Bu hastaların dokuzuna sol subklaviyan arteri (SKA) yolu ile birine ise sağ SKA yolu ile genel anestezi altında TAKY yapıldı. Tüm hastalarda cerrahi açma ve kapama tekniklerinden yararlanıldı. Sekiz hastaya balonla genişleyebilen Edwards Sapien XT (bir 23 mm, altı 26 mm ve bir 29 mm), 1 hastaya Sapien 3 (26 mm), 1 hastaya da kendiliğinden genişleyebilen Lotus (27 mm) kapak takıldı.

Bulgular: İşlem başarı oranı %90 idi. Ortalama aort basınç farkı 47.4 mmHg'dan 10.6 mmHg'ya geriledi. Bir hastada aort kapağın ventriküle embolizasyonu nedeniyle acil cerrahi aort kapak yerleştirme gerekti. Bir hastada sağ subklaviyan arterinde pıhtı oluşumu saptandı ve pıhtı medikal tedavi ile çözüldü. Hiçbir hastada ölüm gözlenmedi.

Sonuç: Subklaviyan yaklaşımı TAKY'de güvenilir ve uygulanabilir bir yoldur. Çok yönlü görüntüleme tekniklerinden faydalanma yanında uygun hasta ve kapak seçimi başarılı ve komplikasyonsuz bir işlem için kritik öneme sahiptir.

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Transcatheter aortic valve implantation (TAVI) has emerged as an alternative treatment to conventional aortic valve replacement (AVR) for high-risk patients with severe degenerative aortic stenosis (AS).[1] It was first performed on a human in 2002 by Alain Cribier, using an antegrade transfemoral vein access site.[1] This technically challenging approach was subsequently replaced with retrograde transfemoral arterial route that is currently the most common route used due to its minimally invasive nature and feasibility under conscious sedation in totally percutaneous fashion. However, peripheral arterial disease (PAD) is relatively common in elderly patients with AS because degenerative aortic valve disease shares many characteristics with atherosclerotic disease.[2] In such patients with unsuitable ilio-femoral arterial systems, alternative routes like transapical and trans-subclavian approaches, as well as direct aortic access, may be considered.[3,4]

Subclavian artery (SCA) has recently become a site of access for TAVI.[5,6] In event femoral access is not possible, SCA is regarded as viable alternative access site for TAVI. Left SCA is usually preferred due to more favorable angle of device as it lies in the aortic annulus.[7] Right SCA is rarely used.[8] In the present study, we share our single-center experience with trans-subclavian aortic valve implantation using Edwards Sapien XT (ESXT), Sapien 3 (S3) (Edwards Lifesciences Corp., Irvine, CA, USA), and Lotus (Boston Scientific Corp., Marlborough, MA, USA) valves.

We aimed to assess safety and feasibility of subclavian access and mention some important points that should be addressed before the procedure.

METHODS

Patient selection

Between June 2011 and May 2016, 273 patients with severe symptomatic AS and excessive surgical risk were evaluated for TAVI in our hospital. A heart team including cardiac surgeon, anesthesiologist, and cardiologist decided to proceed with TAVI based on risk scores (logistic European System for Cardiac Operative Risk Evaluation [EuroSCORE], Society of Thoracic Surgeons [STS], and Surgical Replacement and Transcatheter Aortic Valve Implantation [SURTAVI] results) and co-morbid conditions of patients. All patients underwent transthoracic echocardiography, transesophageal echocardiography, multi-slice computed tomography (MSCT), and coronary angiography with angiography of iliac and femoral arteries and aortography to determine access site; valve size, type, and position during implantation; possible complications; and management strategies and precautions that should be taken before the procedure.

Abbreviations:

AAA	*Abdominal aorta aneurysm*
ABVP	*Aortic balloon valvuloplasty*
AR	*Aortic regurgitation*
AS	*Aortic stenosis*
AVR	*Aortic valve replacement*
CTA	*Computed tomography angiography*
EVAR	*Endovascular aneurysm repair*
LAD	*Left anterior descending*
LIMA	*Left internal mammarian artery*
LV	*Left ventricle*
MSCT	*Multi-slice computed tomography*
PAD	*Peripheral arterial disease*
SCA	*Subclavian artery*
TAVI	*Transcatheter aortic valve implantation*
TAVR	*Transcatheter aortic valve replacement*
TEVAR	*Thoracic endovascular aortic repair*

All patients were initially screened for transfemoral TAVI. In cases where this approach was not suitable, patients were evaluated for first alternative route used in our clinic, trans-subclavian approach. As a result, 263 patients were eligible for transfemoral TAVI, while 10 patients (6 males) with mean age of 68.3±7.6 years, underwent TAVI via subclavian artery route due to small size, severe calcification, tortuosity and severe stenosis of ilio-femoral arteries, history of endovascular aneurysm repair (EVAR) or thoracic endovascular aortic repair (TEVAR), or presence of abdominal aorta aneurysm (AAA). SCA size, course, tortuosity, calcification, and presence or absence of stenosis were evaluated with both MSCT and aortography images. Subclavian access was considered when vessel met minimum diameter requirements, showed no severe kinking, and no calcification was present at origin of the aortic arch. Decision on valve type to be used was based on degree and distribution of calcification, elasticity and plane of aorta, and risk of aortic regurgitation (AR). Collection of data was approved by the local ethics committee and written informed consent of all patients was obtained.

Procedural techniques

All trans-subclavian TAVI procedures were performed under general anesthesia in catheterization laboratory by team comprised of experienced interventional cardiologists, cardiac surgeon, and anesthesiologist. Before the procedure, a 6-F pigtail catheter was advanced in aortic root to allow hemodynamic monitoring and

landmark aortic angiography through right femoral artery in 7 patients, right brachial artery in 2 patients, and left brachial artery in 1 patient. Temporary pacing lead was inserted into right ventricle through right femoral vein in 7 patients and left femoral vein in 2 patients to perform rapid pacing during valvuloplasty and valve deployment and to treat possible complication of atrioventricular block after procedure. Next, subclavian artery was surgically isolated through 3 to 5 cm incision in deltopectoral groove. Surgeon paid particular attention to brachial plexus just superior to SCA. Heparin was administrated to achieve activated clotting time of between 250 and 300 seconds throughout the procedure. A 7-F sheath was then inserted into SCA and Amplatz Super Stiff guidewire (Boston Scientific Corp., Marlborough, MA, USA) was advanced to aortic root. Over this wire, 18-F (9 patients) or 16-F (1 patient) introducer e-sheaths (William Cook Europe ApS., Bjaeverskov, Denmark) was inserted after consecutive predilatations of SCA. After that, 0.038 straight guidewire was placed into left ventricle (LV) through introducer sheath using Amplatz left-1 (AL-1) catheter (Amplatz Cook, Inc., Bloomington, IN, USA). Pressure gradient was measured and AL-1 catheter was exchanged with pigtail catheter. Next, 0.035 in 260 cm Amplatz Extra Stiff guidewire (Boston Scientific Corp., Marlborough, MA, USA) with tip angled to left ventricular apex was inserted into LV over pigtail catheter, and aortic balloon valvuloplasty (ABVP) was performed with rapid pacing in patients receiving balloon expandable bovine ESXT and S3 bioprosthesis. After control aortography, bioprosthesis was also carefully introduced and retrogradely deployed with rapid pacing in patients receiving balloon expandable prosthesis under angiographic and fluoroscopic guidance over the extra stiff wire. A total of 9 ESXT valves (valve-in-valve in 1 patient), 1 S3, and 1 Lotus valve were used in this study. Early hemodynamic improvements were observed in all patients minutes after procedure. Immediately after valve deployment, aortography was performed to evaluate presence or degree of AR, patency of coronary arteries and grefts and position of valve. Heparin was neutralized with antidote protamine sulphate, and access site was closed with direct suture.

Statistical analysis

All statistical analyses were performed using SPSS version 17.0 (SPSS, Inc., Chicago, IL, USA). Incidence rate of complications and events were reported with number of patients experiencing event followed by corresponding percentage. Continuous data were reported giving mean±SD or median and range of values observed.

RESULTS

Baseline characteristics and echocardiographic results of patients undergoing trans-subclavian TAVI are provided in Table 1. As indicated, 9 patients underwent TAVI under general anesthesia via left SCA and 1 patient via right SCA. Mean age of patients was 68.3±7.6 years, and 6 were male. Obesity (body mass index [BMI] ≥30 kg/m^2) was present in 7 (75%) patients, 1 of whom was morbidly obese (BMI: 52.6 kg/m^2). Five (50%) patients were current smokers, 5 patients (50%) had insulin-dependent diabetes mellitus, and all out of 1 patient were hypertensive. Permanent atrial fibrillation, previous coronary artery bypass surgery, or percutaneous coronary intervention (PCI) were present in 30% (3 patients) of patients. There were 2 cases of previous history of stroke, 1 hemorrhagic and 1 ischemic; however, there were no significant sequelae. Reasons for inability to perform transfemoral TAVI were severe ilio-femoral artery stenosis in patient number 7, 8, and 10; severe tortuosity and calcification in patient number 4, 5, and 6; presence of AAA (6 cm in diameter) in patient number 2 and 3; small size (5.5 mm) of femoral arteries in patient number 1; and previous history of EVAR and TEVAR in patient number 9. In patient number 6, transfemoral TAVI was planned, but as result of circular calcification in left common iliac artery 18-F e-sheath failed to pass through and we had to turn to trans-subclavian procedure. There was moderate to severe chronic obstructive pulmonary disorder present in 5 (50%) patients. Eight patients (80%) were evaluated as New York Heart Association (NYHA) Class III, whereas 2 patients (20%) were in NYHA Class IV. Mean logistic EuroSCORE and STS score were 24.5±8.4% and 7.4±5.3%, respectively. According to SURTAVI risk model, 4 patients (40%) were in high risk group, 2 patients (20%) were in moderate risk category, and 1 patient was deemed at low risk. Three patients (30%) could not be evaluated using SURTAVI risk model as they were below 70 years of age.

When we examined baseline echocardiographic features of the patients, it was detected that average

Table 1. Baseline characteristics and echocardiographic results of patients

Variable	Patient number									
	1	2	3	4	5	6	7	8	9	10
Age (years)	79	75	72	85	84	74	75	61	66	58
Gender	Male	Male	Male	Female	Female	Male	Male	Female	Female	Male
Body mass index (kg/m^2)	26	24	32	31	51.5	32	30	30	34	27
Smoking	+	+	–	–	–	–	+	+	–	+
IDDM	–	–	–	+	–	+	+	+	–	+
Hypertension	+	+	+	+	+	+	+	+	+	–
Atrial fibrillation	–	–	–	–	+	–	+	–	–	+
Previous CABG	–	–	–	+	–	+	–	–	–	+
Previous PCI	–	–	–	–	–	–	+	+	+	–
Previous stroke	–	–	–	–	–	+	–	+	-	–
Peripheral arterial disease	+	+	+	–	–	–	+	+	+	+
COPD	+	–	–	–	+	+	+	–	+	–
NYHA FC	3	3	3	3	4	3	4	3	3	3
Logistic EuroSCORE (%)	15.7	6.8	19	19.1	24.2	31.2	19.9	12.6	9.6	87.3
STS score (%)	4.6	3.9	2.9	10.8	11.3	6.8	6.4	2.7	3.4	21.3
SURTAVI	Mod	Mod	Low	High	High	High	High	NA	NA	NA
Aortic valve area (cm^2)	0.7	0.5	0.7	0.4	0.6	0.7	0.7	0.8	0.5	0.7
Max gr (mmHg)	72	89	87	64	62	60	92	78	101	56
Mean gr (mmHg)	47	57	43	48	41	40	44	46	70	38
LVEF (%)	45	70	65	50	50	55	55	65	65	15
sPAP (mmHg)	55	30	45	30	70	35	55	–	30	–

+: Present, –: absent; IDDM: Insulin-dependent diabetes mellitus; CABG: Coronary artery by-pass grafting; PCI: Percutaneous coronary intervention; COPD: Chronic obstructive pulmonary disease; NYHA FC: New York Heart Association functional class; STS: Society of Thoracic Surgeons; SURTAVI: Surgical Replacement and Transcatheter Aortic Valve Implantation; LVEF: Left ventricular ejection fraction; Max gr: Maximum gradient; Mod: Moderate; NA: Not applicable; sPAP: Systolic pulmonary artery pressure.

peak and mean aortic valve gradients and aortic valve area of patients were 76.1±12.8 mmHg, 47.4±5.3 mmHg, and 0.63±0.17 cm^2, respectively. Mean left ventricular ejection fraction and systolic pulmonary artery pressure were calculated at 53.5±4.8% and 35.1±15.7 mmHg, respectively.

Procedural features are presented in Table 2. ESXT valves were inserted through left SCA in 7 patients and right SCA in 1 patient. The remaining 2 patients received Lotus valve and S3 valve through left SCA. Procedure was performed on patient number 4 through right SCA due to presence of patent left internal mammarian artery (LIMA) greft on left anterior descending (LAD) coronary artery. For patient number 6, also with patent LIMA greft on LAD artery, left SCA was preferred as access site due to inappropriate size of right SCA. Aortic balloon valvuloplasty was performed on patients receiving balloon-expandable Sapien valves, but not on patient receiving self-expandable Lotus valve. Mean duration of procedure was 105±31 minutes, with average fluoroscopy time of 29±10 minutes. Procedural success was obtained in 90% (n=9) of the patients. ESXT valve embolized into LV minutes after deployment in patient number 8, and patient's hemodynamic stability was disrupted immediately. After informing cardiovascular surgeons, we attempted to implant another ESXT valve to prevent further acute hemodynamic decompensation and buy time until open surgical intervention. However, second valve also embolized into LV. Patient underwent immediate open surgical aortic valve replacement with a St. Jude 21 mm mechanical prosthesis (St. Jude Medical, Inc., Little Canada, MN, USA) and

Table 2. Procedural and post-procedural features of patients

Variable	Patient number									
	1	2	3	4	5	6	7	8	9	10
Access site	Left	Left	Left	Right	Left	Left	Left	Left	Left	Left
Access&closure	S	S	S	S	S	S	S	S	S	S
Valve type	SXT	SXT	SXT	SXT	SXT	Lotus	S3	SXT	SXT	SXT
Valve size (mm)	26	26	26	23	26	27	26	26	26	29
Implantation time (min)	84	78	121	74	136	156	102	122	76	104
Flouroscopy time (min)	18	28	32	18	42	44	26	38	22	29
Aortic valve area (cm^2)	2.1	2.2	2.4	1.8	2.1	1.6	1.7	–	2.1	
Max gr (mmHg)	17	19	20	15	13	42	31	–	32	11
Mean gr (mmHg)	10	12	8	8	6	23	19	–	14	6
Aortic regurgitation degree	None	Mild	Mild	None	None	None	Mild	–	None	None
LVEF (%)	45	70	65	55	55	60	40	–	65	37
Complication	–	–	–	+	–	–	–	+	–	–
Death	–	–	–	–	–	–	–	–	–	–

LVEF: Left vetricular ejection fraction; Max gr: Maximum gradient; S: Surgical cut down; S3: Sapien 3 valve; SXT: Edwards SAPIEN XT valve.

was taken to coronary care unit. Patient's condition subsequently improved and patient was discharged from the hospital. Cause of this complication was independent of access site and assumed to be due to rheumatological etiology of AS and relatively young age of patient. Absent of degeneration prevented firm anchoring of valve to aortic root and relatively well preserved elasticity of aorta led to shift of valve into LV. After removal of e-sheath and surgical closure of SCA, all patients were extubated in catheterization laboratory and transthoracic echocardiography was performed to exclude possible complications like pericardial effusion and to examine function of aortic bioprosthesis. Patients were then transferred to coronary care unit and monitored. There was no need for permanent pacemaker implantation in any patient on follow-up; however, patient number 4, who underwent TAVI via right SCA, complained of numbness and coldness in right hand 3 days after the procedure. Physical examination revealed absent radial pulse. To clarify diagnosis and exclude possible complication of SCA dissection, computed tomography angiography (CTA) was performed and revealed 5 cm thrombus formation beginning 2 cm after separation of vertebral artery from SCA and permitting the passage of blood. Cardiovascular surgery department was consulted and they decided to perform close follow-up of peripheral pulses and check for clues of ischemic signs and symptoms. Patient made full recovery; Doppler ultrasonography and CTA showed normal blood flow with absent thrombus in SCA. This patient was also subsequently discharged from the hospital with complete cure.

Mean aortic valve gradient decreased to 10.6 mmHg from baseline value of 47.4 mmHg. In addition, aortic valve area was increased to 2.1 cm^2 from baseline 0.63 cm^2. Degree of paravalvular leak was not more than mild, and in-hospital mortality was not observed. Furthermore, permanent pacemaker implantation was not required, and no adverse neurological events were detected in any of the patients.

DISCUSSION

TAVI is an evolving therapy providing relief to AS patients with high surgical risk.[9,10] It is a complex procedure and large number of complications are possible. The most commonly observed complications are vascular and related to access site. Because it is minimally invasive, and as it is feasible under conscious sedation, standard approach for TAVI is through transfemoral retrograde route. Ilio-femoral arteries enable relatively large profile (18-F) device introducer sheath and delivery catheters requiring access route with diameter larger than 6 mm. However, in case of inappropriate

transfemoral vascular access site due to small or diseased ilio-femoral arteries, alternatives like transapical or trans-subclavian route, or direct aortic access through thoracotomy can be utilized.

Transapical approach allows introduction of delivery systems directly through apex of LV without sheath diameter limitation. This approach is more invasive, usually requires general anesthesia, minithoracotomy, and incision of LV apex. Moreover, structural change of LV due to remodeling and distorted angle in severe AS patients further increase risks of transapical TAVI.[5] Direct aortic access is somewhat similar to surgical aortic valve implantation due to need for general anesthesia and cardiovascular surgeons. In this scenario, as recently reported by some authors, trans-subclavian approach could represent an attractive alternative to transfemoral TAVI with severe ilio-femoral arteriopathy.[5,8,11] SCA is easily reachable after surgical cut-down and its size allows introduction of 18-F sheath. It can also be safely performed under deep sedation with administration of mild systemic sedatives and analgesic agents. Therefore, trans-subclavian approach is now preferred alternative to transfemoral TAVI when necessary due to PAD in patients with severe AS requiring TAVI procedure.

Recent studies have determined that safety of trans-subclavian TAVI is not inferior to transfemoral TAVI.[12] Petronio et al.[6] reported 100% procedural success and 0% intraprocedural mortality rates based on analysis of 54 patients who underwent trans-subclavian TAVI procedure with CoreValve ReValving system (Medtronic, Dublin, Ireland). In addition, there were no significant differences in 30-day and 6-month mortality rates compared with transfemoral TAVI. Moynagh et al.[13] demonstrated that although trans-subclavian TAVI patients had significantly higher EuroSCOREs because of frequent incidence of PAD, coronary artery disease, prior myocardial infarction or prior PCI, it was better than transfemoral approach in terms of optimal valve positioning and major adverse cardiovascular and cerebrovascular events. Medtronic CoreValve ReValving system was also used in this study.

In the present trans-subclavian series, we avoided performing transfemoral TAVI on 2 patients with AAA, which can pose a hazard to passage and device insertion if sheath enters the aneurysm itself. Ilio-femoral route for patients with AAA is possible with a sheath with enough length to extend above the aneurysm. However, vascular complications are common with TAVI and can increase early and late mortality, and these complications are best avoided by careful patient selection and selecting an alternative route in questionable cases. Vascular complications in present TAVI series were low,[14] proving accuracy of our cautious approach. We also elected not to perform transfemoral TAVI on 3 patients with extreme ilio-femoral tortuosity and calcification. Most tortuosity can be straightened adequately enough for sheath insertion after placement of a stiff wire, but extreme tortuosity should be avoided, as it may result in kinking of sheath and failure of device delivery.

Since left SCA allows more co-axial orientation of valves with aortic root and annulus, we preferred left SCA in all but 1 instance in this study. Right SCA may also be used in appropriate cases with favorable anatomical configuration, and has procedural results similar to those of left subclavian access;[15] however, right SCA cannot be standard access site for trans-subclavian TAVI cases due to additional technical challenges. First, when coming from right SCA, it is important to take care that e-sheath remains distal to origin of right common carotid artery so as not to prevent blood flow to brain. Second, angle between delivery catheter and axis of ascending aorta is usually greater than from left SCA, making insertion of e-sheath, and thus implantation of prosthesis, difficult. For those reasons, we avoided performing TAVI via right SCA as much as possible, and suggest that right subclavian access site should be used only when left subclavian access is not feasible and orientation of aorta is not horizontal. We performed TAVI via right SCA in 1 patient with coronary artery bypass grafting in order to avoid greater risk of myocardial ischemia by hindering LIMA greft.

Moreover, in contrast to transfemoral TAVI procedures where e-sheath is inserted before advancing into LV, in trans-subclavian TAVI cases we first advanced Amplatz Super Stiff wire into LV and then inserted e-sheath into SCA for extra support. In trans-subclavian TAVI procedure, loading of bioprosthetic valve over balloon is performed at ascending aorta, rather than descending aorta as in transfemoral TAVI; the extra support of stiff wire is critical for successful procedure.

Another important point that should be mentioned regarding left subclavian access for TAVI is case

with presence of patent LIMA greft to LAD artery. Insertion of almost occlusive 18-F sheath may result in myocardial ischemia by hindering blood flow to LIMA greft. To prevent such a complication, SCA diameter should be larger than usually needed and free of atherosclerotic disease. To minimize myocardial ischemic time, we performed ABVP through smaller sheath before inserting and advancing e-sheath. In addition, 18-F e-sheath was withdrawn distal to origin of LIMA just after valve deployment. Two patients in this study with patent LIMA greft underwent TAVI via left SCA without complications during or after procedure.

Although trans-subclavian TAVI has some disadvantages and challenges, it also has advantage of enabling shorter access to aortic valve. Valve delivery catheter takes a less remote distance and avoids becoming bent in tortuosities of ilio-femoral and thoracoabdominal axis. This improves control of bioprosthetic valve during implantation and allows for more accurate device positioning, thus reducing complications like paravalvular leak or complete atrioventricular block requiring permanent pacemaker implantation. In present study, there was no more than mild degree of paravalvular leak and none of the patients required permanent pacemaker.

Our experience confirmed that not only CoreValve, but also ESXT, S3, and Lotus valves can be used in patients undergoing trans-subclavian TAVI. Procedural success rate of our series was 90% as result of need for the requirement of emergent surgical AVR in 1 patient due to ventricular embolization of bioprosthesis. Complication was likely result of rheumatic disease of aortic valve and relatively protected elasticity of aorta rather than technical difficulty. None of the study patients had adverse neurological events or required permanent pacemaker implantation after procedure. Except for subclavian artery thrombosis in 1 patient, no other vascular or bleeding complications were observed. No surgical wound infections occurred, and all patients were discharged in good health with stable hemodynamic compensation.

Limitations of the study

Major limitation of the present study is relatively small number of patients who underwent TAVR through subclavian artery. Therefore, future large-scale studies are needed to generalize our results.

Conclusions

Trans-subclavian TAVI is safe and feasible in patients with unfavorable ilio-femoral route using various valve types in addition to CoreValve. It should be first alternative to consider in patients not only with contraindications for transfemoral approach, but also those who appear to be at higher risk of peripheral vascular complications in case of applicable but difficult transfemoral approach. Therefore, for all patients who will undergo TAVI, suitability of subclavian arteries should also be evaluated comprehensively in addition to ilio-femoral arteries prior to procedure.

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