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Wire pull-through technique using a double lumen sheath during transapical transcatheter aortic valve implantation

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KEYWORDS

- aortic stenosis
- radial
- transapical
- transcatheter aortic valve implantation

Abstract

Transapical transcatheter aortic valve implantation (TA-TAVI) with the wire pull-through technique using a double lumen sheath via the brachial or radial artery is a new therapeutic approach to aortic stenosis patients having shaggy aortic arch. The risk of systemic embolisation of atherothrombotic material can theoretically be reduced by avoiding any manipulations of stiff guidewires or catheters across the diseased segments based on the "non-touch" method. We report a case series of three patients undergoing the wire pull-through technique during TA-TAVI using the SAPIEN XT transcatheter heart valve. The rationale, technical considerations and clinical implications of this technique are described.

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Introduction

Transcatheter aortic valve implantation (TAVI) has been developed as an alternative therapeutic approach to surgical aortic valve replacement (SAVR) for high-risk or inoperable patients with symptomatic aortic stenosis (AS). In patients with AS, shaggy aorta is frequently observed by ultrasonography or computed tomography (CT). It has been reported that the presence of shaggy aorta is associated with serious complications during surgical or endovascular procedures due to embolisation of atherosclerotic or thrombotic materials[1]. In patients undergoing endovascular aneurysm repair, atherothrombotic embolisation presenting with systemic organ ischaemia (e.g., brain, bowel, or limb) was observed in 5.0-7.8% of cases, but it might result in catastrophic consequences (in-hospital mortality: 50-80%)[2,3]. The transapical (TA) approach instead of the transfemoral (TF) is thus generally accepted as the optimal treatment strategy in patients having shaggy aorta. Despite the lack of evidence, however, the conventional TA-TAVI technique still has a potential concern in terms of disruption of atherothrombotic mass and subsequent systemic embolisation by manipulating stiff guidewires or catheters.

The current report presents three cases undergoing TA-TAVI with the wire pull-through technique using a double lumen sheath. The technical considerations and clinical implications of this technique are also discussed.

Rationale and procedural technique

A rationale of the wire pull-through technique – non-touch method – is to avoid manipulations of any devices into shaggy aortic arch. This approach could minimise the risk of atherothrombotic embolisation that may result in serious post-procedural complications. Using a double lumen sheath via the brachial or radial artery, a 0.035-inch wire and a pigtail catheter or a guiding catheter can be inserted simultaneously in a sheath.

Preparing for the wire pull-through technique, a double lumen sheath (Medikit, Tokyo, Japan) has to be inserted via the right brachial or radial artery. Following the needle puncture to the left ventricle (LV) wall, a hydrophilic soft wire with angle-shaped tip (Radifocus® Guidewire M Standard type; Terumo Corp., Tokyo, Japan) is advanced into the right subclavian artery (SCA) together with a coronary diagnostic catheter (e.g., Judkins right or multipurpose). After replacing the soft wire with a hydrophilic half-stiff wire (Radifocus® M Half stiff type; Terumo Corp.), it should be advanced distally to the snaring system (Indy OTW™ Vascular Retriever [Cook Medical, Bloomington, IN, USA]; EN Snare® [Merit Medical Systems, South Jordan, UT, USA]). The wire can be caught easily and retrieved through the sheath **(Figure 1)**. After establishing the pull-through system, the diagnostic catheter is removed and a pigtail catheter is introduced retrogradely through another port of the double lumen sheath. The following procedure after the insertion of a 24 Fr Ascendra+ sheath (Edwards Lifesciences, Irvine, CA, USA) is the same as that of conventional TA-TAVI using the SAPIEN XT (Edwards Lifesciences).

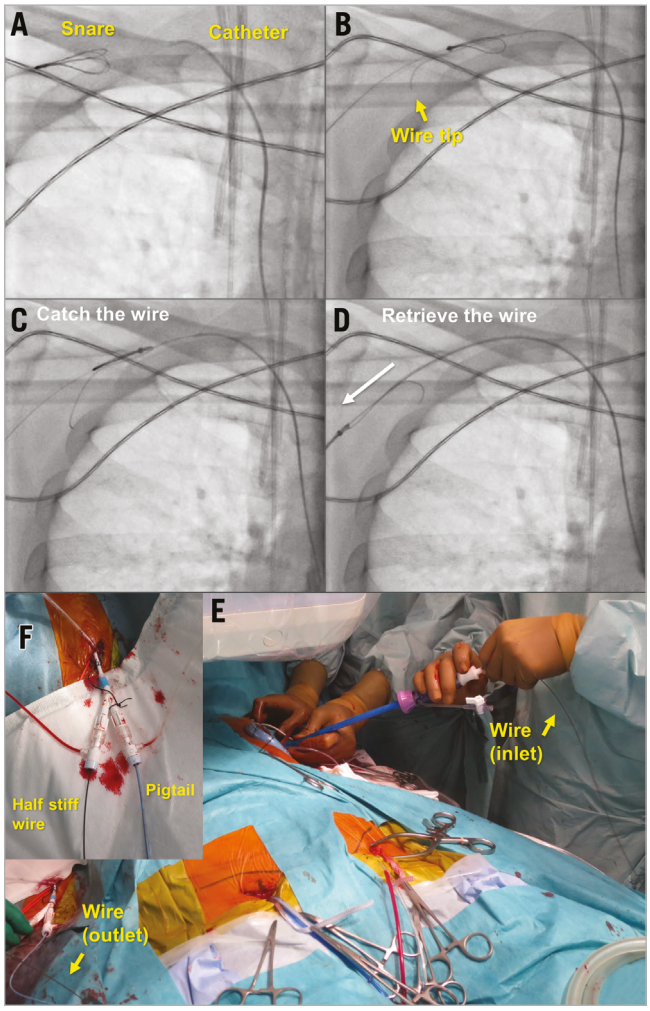

Figure 1. *Wire pull-through technique during TA-TAVI. A snaring system and a Judkins Right diagnostic catheter are placed in the right subclavian artery (A). The wire is advanced distally to the snaring system introduced through the double lumen sheath (B, yellow arrow). The wire can be grasped easily (C) and retrieved through the sheath (D). After establishing the wire pull-through system, the diagnostic catheter is removed (E), then a pigtail catheter is retrogradely introduced through another port of the double lumen sheath (F).*

Results

Three cases treated with the wire pull-through technique are summarised in **Table 1**. In brief, mean age was 86 and all patients were frail and male. Average STS score (30-day mortality) and logistic EuroSCORE were 8.3% and 14.3%, respectively. One patient (Case 2) was diagnosed as having classical low-flow low-gradient AS based on dobutamine stress echocardiography. Multidetector CT (MDCT) revealed significant shaggy aortic arch in all cases **(Figure 2)**. Regarding the double lumen sheath, an 8 Fr via brachial cut-down was used for our first two cases and a 6.5 Fr via radial puncture was used for the third case. Post-procedural paravalvular leak was acceptable (i.e., mild or trace) in all cases. Two patients were discharged 10 days after the procedure without any

Table 1. Clinical and procedural characteristics of three representative cases.

	Case 1	Case 2	Case 3
Demographics			
Age (years)	89	83	87
Sex	Male	Male	Male
Height (cm)	161	160	150
Weight (kg)	50	51	48
Body surface area (m^2)	1.50	1.51	1.40
Hypertension	Yes	Yes	Yes
Diabetes mellitus	Yes	No	No
Dyslipidaemia	No	No	Yes
Current smoking	No	No	No
Prior cerebrovascular accidents	No	No	No
Prior myocardial infarction	No	Yes	No
Prior PCI	No	No	No
Prior CABG	No	Yes	No
Preoperative risk assessment			
Atrial fibrillation	No	Yes	No
Chronic kidney disease	Yes	Yes	No
Chronic obstructive pulmonary disease	No	Yes	No
Peripheral artery disease	No	No	No
Steroid or immunosuppressant use	No	No	No
Estimated glomerular filtration rate (mL/min/1.73 m^2)	27.6	42.8	50.5
NT-proBNP (pg/mL)	10,152	1,918	5,226
STS 30-day mortality rate (%)	10.1	8.3	6.5
Logistic EuroSCORE (%)	10.1	23.9	9.0
CSHA frailty scale	5	5	4
Imaging assessment			
Aortic valve area (cm^2)	0.52	0.63	0.54
Mean pressure gradient (mmHg)	85	26	83
Peak velocity (m/s)	5.9	3.4	6.0
Left ventricular ejection fraction (%)	55	42	65
Preoperative aortic regurgitation	Trivial	Mild	Mild
Annulus perimeter (mm)	70.4	76.3	73.7

	Case 1	Case 2	Case 3
Imaging assessment			
Annulus diameter (mm)			
TTE	19.5	19.8	19.2
TEE	19.4	20.8	21.5
CT	21.9	24.3	22.8
Annulus area (mm^2)			
TEE	352	361	396
CT	360	440	407
Mean STJ diameter on CT (mm)	29.9	32.9	32.9
Mean diameter of sinus of Valsalva (mm)	33.9	33.8	30.6
Subannular calcification	No	Yes	No
Aortic aneurysm	No	Yes	Yes
Shaggy aorta	Yes	Yes	Yes
Penetrating aortic ulceration	Yes	No	No
Procedures			
Anaesthesia	General	General	General
Guidewire	extra-stiff	half stiff	half stiff
Size of double lumen sheath (Fr)	8.0	8.0	6.5
Vascular access site	Brachial	Brachial	Radial
Sheath insertion technique	cut-down	cut-down	puncture
Pre-BAV balloon size (mm)	20	skipped	20
SAPIEN XT THV size (mm)	23	26	26
Balloon inflation volume	Nominal	–1 mL	–2 mL
Postoperative paravalvular leak	Mild	Mild	Trace
Procedural complications	No	Worsening of interstitial pneumonia	No
Hospital stay after the procedure (days)	10	35	10

BAV: balloon aortic valvuloplasty; CABG: coronary artery bypass graft; CSHA: Canadian Study of Health and Aging; CT: computed tomography; PCI: percutaneous coronary intervention; STJ: sinotubular junction; STS: Society of Thoracic Surgeons; TEE: transoesophageal echocardiography; THV: transcatheter heart valve; TTE: transthoracic echocardiography

complications. Another patient (Case 2) who suffered from worsening of interstitial pneumonia was discharged 35 days after the procedure.

Discussion

To our knowledge, this is the first description of the wire pull-through technique using a double lumen sheath during the TA-TAVI procedure. Despite our early experience, the current report highlights the safety and feasibility of this technique specifically for patients having shaggy aortic arch.

The bottom line for applying this technique was that the majority of TAVI patients were elderly, usually above the age of 80, and probably with associated atherosclerotic disease of the aortic arch, in which this technique would be beneficial in reducing the thromboembolic risk. A previous study indicated that post-procedural magnetic resonance imaging revealed evidence of cerebral embolism in 84% of patients undergoing TF-TAVI[4]. Another study demonstrated that severe atheroma in the aortic arch and descending aorta appeared to be a predictor of cerebral infarction after TAVI, despite the fact that the majority of patients were clinically silent[5,6]. An embolic deflector device is expected to be an attractive solution and has been clinically tested in order to establish whether the risk of post-procedural cerebral infarction can be reduced[7]. Although the pathogenesis and origin of embolic materials have not been fully investigated, the TA-TAVI procedure without any device manipulations across diseased aortic segments might reduce the risk of systemic embolisation of atherothrombotic materials.

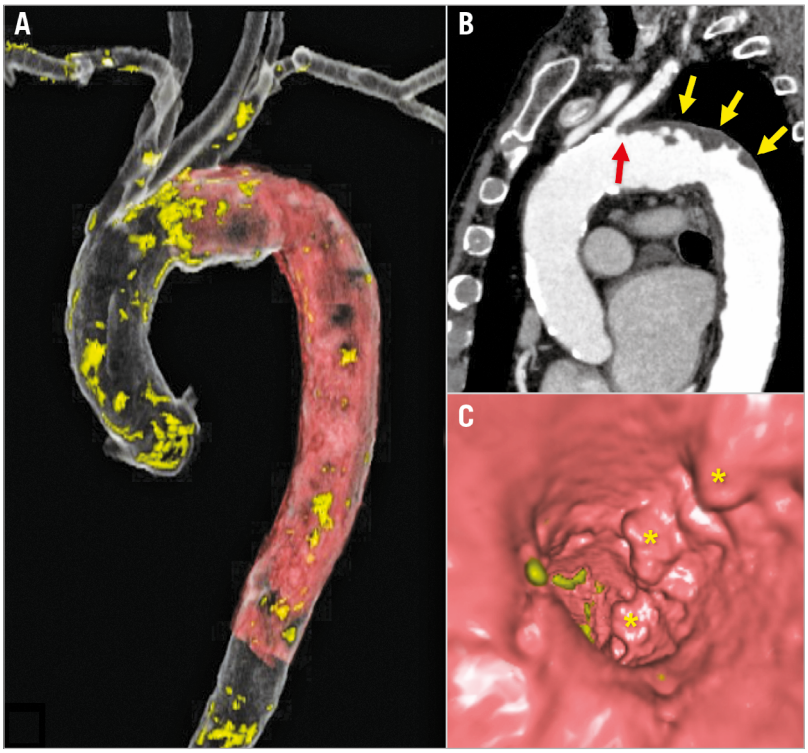

Figure 2. *Computed tomography assessment of shaggy aorta. Distribution of calcification is highlighted in yellow and atherothrombotic material is highlighted in red in a three-dimensional volume-rendered image (A). An irregular-shaped atheroma was diffusely observed in the aortic arch (B, yellow arrows) and the ostium of the left subclavian artery was also involved (B, red arrow). Upstream fly-through view indicated that the atheroma was protruding into the aortic lumen (C, asterisks).*

Toyota et al reported the wire pull-through technique via the femoral artery in a TA-TAVI case with kinked guidewire and unsuccessful passage of a THV system through the aortic valve[8]. Bagur et al reported the "no-touch" technique by placing a stiff wire distally into the right SCA during TA-TAVI[9]. A potential advantage of our wire pull-through technique is that it ensures substantial back-up force of the wire in order to deliver and stabilise the THV system. Furthermore, as the wire is grasped and retrieved, we will never have the problem of losing the wire or penetrating small side branches (i.e., wire perforation). It is quite easy for skilled interventional cardiologists to deliver the wire and diagnostic catheter to the SCA, while preoperative three-dimensional CT will be useful for wiring navigation.

A double lumen sheath offers another vascular access for a pigtail catheter or a guiding catheter when coronary protection or subsequent percutaneous coronary intervention (PCI) is needed. A 4 Fr pigtail catheter is compatible for a 6.5 Fr sheath, and a 6 Fr guiding catheter is compatible for an 8 Fr sheath in the setting of a 0.035-inch wire already inserted in the sheath. Although bilateral brachial/radial access is an alternative option, there are several concerns to be considered: 1) single vascular access rather than double is less likely to be associated with vascular complications, 2) single-side (right-side) approach does not interfere with the operators or anaesthesiologists (e.g., arterial blood pressure monitoring via the left radial artery), and 3) atheroma in the aortic arch sometimes involves the ostium of the left SCA as shown in **Figure 2**. It should also be noted that we were able to downsize the double lumen sheath from 8 Fr to 6.5 Fr during our experience, and a 6.5 Fr sheath could be introduced via the radial artery (Case 3). None of our cases entailed vascular complications, something which may also benefit patients by reducing the risk of nerve injury by brachial access.

Limitations

This technique has some potential limitations. First, the procedures require additional equipment/cost and procedural time compared to conventional TA-TAVI. In our experience, however, the pull-through system could be established within five minutes after introducing a 6 Fr sheath to the LV apex. In addition, our procedure became less invasive owing to the fact that we shifted from surgical cut-down to puncture for introducing the double lumen sheath as it was downsized from 8 Fr to 6.5 Fr. This may contribute to shortening the procedure time. Second, even in cases with THV migration into the ascending aorta, the THV will never be overturned because the wire is grasped outside the sheath. In this scenario, surgical retrieval of the migrated THV might be safer than percutaneous bail-out by implanting a THV in the descending aorta, which may result in catastrophic embolisation to systemic organs.

Conclusions

The wire pull-through technique using a double lumen sheath was safe and feasible in TA-TAVI for AS patients with shaggy aortic arch or penetrating aortic ulceration.

Impact on daily practice

The wire pull-through technique using a double lumen sheath could be an optional strategy during TA-TAVI when the Heart Team has a potential concern about embolic complications due to the presence of significant atherothrombotic mass detected in the aortic arch.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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