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ORIGINAL PAPER

A safe and simple technique for crossing stenotic aortic valves

Wolfgang Schoels[1] · **Marwan S. Mahmoud**[2] · **Mathias Kullmer**[1] · **Mohamad Dia**[3]

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Abstract

Objectives To describe and to validate a new technique for crossing stenotic aortic valves (AV).

Background Current techniques for crossing the AV may be time-consuming and hazardous.

Methods One hundred consecutive patients with severe aortic stenosis treated by transfemoral TAVI were prospectively selected to have an initial attempt of 5 min to cross the AV with a novel pigtail/J-wire technique before switching to the conventional Amplatz®/straight wire approach. For the pigtail/J-wire technique, the catheter is placed 3–4 cm above the AV and turned anteriorly in the 30° RAO view. A J-wire pushed out of the pigtail-catheter will reach the anterior wall of the ascending aorta, forming a u-shaped curve above the AV. The height of the pigtail catheter determines the width of the curve, rotation will help to find an orientation, where the vertex of the curved J-wire easily passes the AV. We analyzed the primary success rate within 5 min and the mean crossing time required.

Results Patients were 83.5 ± 5.5 years of age and predominantly male (62%). Primary success rate was 86%, AV crossing took 48.2 ± 34.6 s without complications. Fourteen failed cases were successfully managed with AL1- (6) and both, AL1- and AL2-catheters (8), respectively

Conclusions The pigtail/J-wire technique for AV crossing is safe, simple and fast. Primary placement of a pigtail catheter into the left ventricle at a success rate of 86% facilitates TAVI procedures.

Keywords Transcatheter aortic valve implantation (TAVI) · Aortic stenosis · Valve crossing

Abbreviations

AV	Aortic valve
TAVI	Transcatheter aortic valve implantation
AL	Amplatz left
RAO	Right anterior oblique
PCI	Percutaneous coronary intervention
STS	Society of thoracic surgery score

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✉ Wolfgang Schoels
wolfgang.schoels@evkln.de

1 Department of Cardiology, Duisburg Heart Center, Gerrickstrasse 21, 47137 Duisburg, Germany

2 Department of Cardiology, Assiut University Heart Hospital, Assiut University, Assiut, Asyut, Arab Republic of Egypt

3 Department of Cardiac Surgery, Duisburg Heart Center, Duisburg, Germany

Introduction

Over the last decade, transcatheter aortic valve implantation (TAVI) has evolved as the treatment of choice for the majority of elderly patients with symptomatic severe aortic stenosis [1]. Retrograde crossing of the aortic valve (AV) is an essential step not only during TAVI procedures [2], but also during diagnostic procedures in uncertain cases.

Commonly, a left Amplatz® catheter (Boston Scientific, Marlborough, MA, USA) and a soft straight-tip wire are used to cross the AV. This is done under fluoroscopic guidance in the left anterior oblique projection to minimize the risk of engaging the ostia of the coronary arteries with the wire. Once in the left ventricle, the Amplatz® catheter is exchanged for a pigtail catheter (Cordis Corporation, East Bridgewater, New Jersey), which then allows to introduce a precurved stiff wire (e.g., Safari®, Boston Scientific, Marlborough, MA, USA) required for TAVI procedures [2, 3]. The Amplatz®/straight wire technique tends to be tidious and time consuming. There is a considerable risk of complications like dissection of the coronary ostia, cerebral embolism, left ventricular injury or hemopericardium [4–6].

Furthermore, the two-step exchange required to introduce a pre-curved stiff wire into the left ventricle prolongs the procedure time and may result in loss of the wire position.

The increasing number of TAVI procedures performed implies a need for better techniques to cross severely stenotic aortic valves. We describe such a technique involving a one-step pigtail approach, validated regarding success rate and passage time during transfemoral TAVI procedures.

Methods

Study design

The study was approved by the local ethics committee. One hundred consecutive patients with severe symptomatic aortic stenosis (aortic valve area [AVA] ≤ 1 cm^2 or indexed AVA ≤ 0.6 cm^2/m^2) receiving transfemoral TAVI at Duisburg Heart Center, Duisburg, Germany, were prospectively selected to have a standardized attempt at crossing the AV with the pigtail/J-wire technique over 5 min. In case of failure, the conventional Amplatz®/straight wire approach was applied. Success rate was defined as the proportion of cases, where the AV could be crossed within 5 min. The clock was started at the moment the J-wire was pushed out of the pigtail catheter, and it was stopped once the wire entered the left ventricle, thus defining the passage time. The J-wire was then used to guide the pigtail catheter into the left ventricle, before being exchanged for a stiff precurved wire (e. g., Safari®). In all patients, the TAVI procedure was completed successfully thereafter, with implantation of Edwards Sapien 3® valves, Medtronic Evolut Pro® or Evolut R® valves, and St. Jude Portico® valves in 53, 29, 2 and 16 patients, respectively. Routine work-up after the TAVI procedure included clinical neurological examination, 12 lead ECG, echocardiography and troponine T measurements. Based on clinical judgement, additional tests (e. g., CT scan, coronary angiography) were applied whenever appropriate. Detection of potential complications relied on this stepwise diagnostic approach.

The pigtail/J-wire technique

Since crossing of the AV was part of a transfemoral TAVI procedure, all patients were in a conscious sedated state and received local anaesthesia for both groins. A 5 F electrode catheter was placed in the right ventricular apex through the left or right femoral vein, and a 5 F pigtail catheter was positioned in the ascending aorta through the left or right femoral artery, intended to be used for contrast dye injection during the subsequent valve implantation. Depending on the anatomy of the pelvic arteries, access to the more suitable of the two femoral arteries was obtained by arterial cut down. A large sheath was introduced according to the type of valve selected (Edwards Sapien 3®, Medtronic Evolut R® or Evolut Pro®, St. Jude Portico®). Through this sheath, a pigtail catheter on a J-wire was placed in the ascending aorta, approximately 3–4 cm above the valvular plane, and turned anteriorly in the 30° RAO view (Fig. 1). When pushing the J-wire out of the pigtail-catheter in this position, it forms a u-shaped curve directly above the aortic valve, the distal end of the wire reaching the anterior wall of the ascending aorta. The width of the u-shaped curve can be modified by changing the height of the pigtail catheter, aiming for a relatively tight vertex. Slight rotational movements of the pigtail catheter may be needed to find an orientation, where forward movement of the wire makes the vertex of the curve pass the aortic valve. As mentioned above, we took the time from the moment the J-wire was pushed out of the pigtail catheter until it passed the valve ("crossing time") or, in case of failure, until the 5 min limit was reached.

Statistical analysis

Data were collected and analyzed using the IBM SPSS® program (IBM Corp., Armonk, NY, USA) v.24. Continuous data are expressed as mean ± SD and non continuous data as percentage (%).

Results

Study population

Baseline characteristics of the study group were typical of a TAVI population, particularly regarding age, comorbidities and STS risk score. Demographic data are summarized in Table 1.

Echocardiographic findings (Table 2)

The majority of patients had normal or only slightly impaired left ventricular ejection fraction. Aortic valve area was severely reduced in all cases, only a minority presented with low flow low gradient aortic stenosis.

Valve crossing with the pigtail/J-wire technique

In 86% of all cases, the valve could be crossed within 5 min, taking a median time of 30 s (range 2—298 s). Success rate increased from 82.5% in the first 40 cases to 86.6% in the next 30 cases and reached 90% in last 30 cases. In the majority of patients, successful crossing of the valve occurred rather fast, that is, within 1 or 2 min. After that time, further attempts were less promising (Fig. 2).

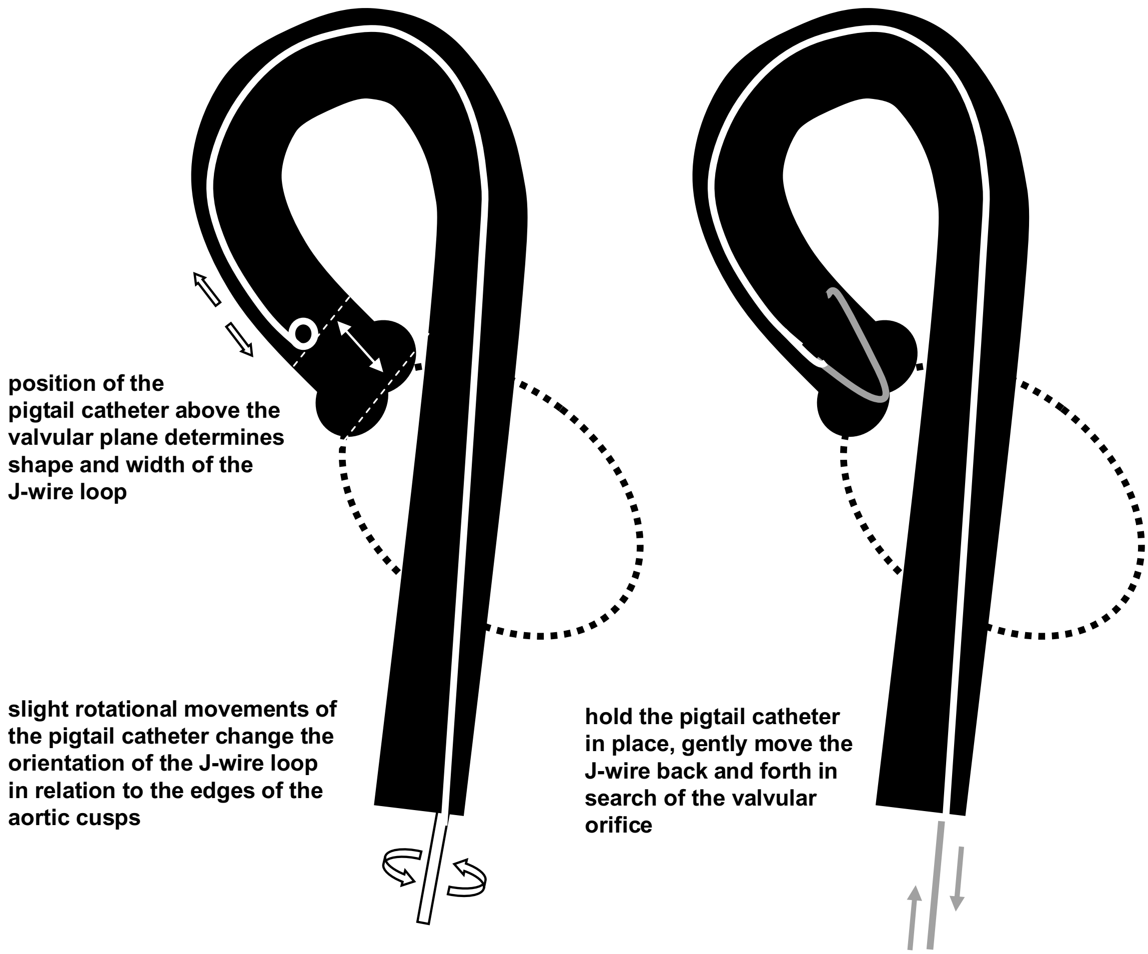

Fig. 1 Technical steps of the pigtail/J-wire technique

In failed cases ($n=14$), the aortic valve was subsequently crossed with the Amplatz® left/straight wire technique. Trying the Amplatz® left-1 curve was sufficient in 6 patients, whereas two curves (Amplatz® left-1 and Amplatz® left-2) had to be engaged in 8 patients. This also indicates that in 57% of cases with failed pigtail/J-wire attempts, two additional catheters were needed to finally succeed (8 of 14 patients).

Successful and failed cases of AV crossing with the pigtail/J-wire technique did not reveal any significant differences regarding echocardiographic parameters (Table 2). Failed cases appeared to be younger, taller and healthier (Table 1), but this might have reflected a play of chance given the small numbers.

Complications

None of the patients experienced a clinically evident complication. In particular, there was no hemopericardium, no coronary event and no neurological sign or symptom.

Discussion

We describe a safe and simple technique to cross severely stenotic aortic valves employing a pigtail catheter and a J-wire in the 30° RAO view on fluoroscopy. This technique was validated during TAVI procedures, yielding a success rate of almost 90% within five minutes and taking less than one minute on average. As expected with a soft pigtail catheter and an atraumatic J-wire, we did not observe any complications. A J-wire is not expected to engage with the ostia of the coronary arteries. Thus, it is safe to rely on the RAO view, which is helpful to confirm the anterior orientation of the pigtail catheter and of the loop of the J-wire.

The most common type of aortic stenosis is the calcified age associated degeneration, where calcium deposition and nodule formation along the flexion lines of the aortic cusps lead to a restriction of leaflet mobility [7]. The edges of the cusps are raised, and the remaining valvular orifice is slit- or star-shaped. To cross the valve, a straight wire needs to be centered directly above the orifice. Otherwise, the calcified, elevated edges of the cusps tend to divert it laterally. A

Table 1 Baseline characteristics of enrolled patients with successful ($n = 86$) or failed ($n = 14$) AV crossing using the pigtail/J-wire technique

Variable	Successful crossing	Failed crossing	*p* value
Age (years)	84.1 ± 5.3	79.4 ± 5.2	**< 0.001**
Sex			0.31
Male	52 (60.5%)	10 (71.4%)	
Female	34 (39.5%)	4 (28.6%)	
Height (m)	1.69 ± 0.76	1.74 ± 0.76	**0.01**
Body surface area (m^2)	1.85 ± 0.21	1.96 ± 0.17	0.09
Hypertension	61 (70.9%)	8 (57.1%)	0.23
Diabetes mellitus	27 (31.4%)	3 (21.4%)	0.34
Hyperlipidemia	47 (54.7%)	6 (42.9%)	0.29
Ischemic heart disease	65 (75.6%)	11 (78.6%)	0.55
Previous PCI	43 (50%)	4 (28.6%)	0.11
Peripheral arterial disease	11 (12.8%)	2 (14.3%)	0.57
Respiratory disease	15 (17.4%)	2 (14.3%)	0.56
Cerebrovascular stroke	5 (5.8%)	0 (0%)	0.46
NYHA Class			0.39
II	23 (26.7%)	6 (42.9%)	
III	60 (69.8%)	8 (57.1%)	
IV	3 (3.5%)	0 (0%)	
Rhythm			0.18
Sinus rhythm	47 (54.7%)	10 (71.4%)	
Atrial fibrillation	39 (45.3%)	4 (28.6%)	
STS score (%)	4.35 ± 1.78	2.87 ± 0.91	**< 0.001**
Low risk	38 (44.2%)	13 (92.9%)	
Intermediate risk	43 (50%)	1 (7.1%)	
High risk	5 (5.8%)	0 (0%)	

p-values indicating a significant difference are in bold

Table 2 Echocardiograhic findings in patients with successful ($n = 86$) or failed ($n = 14$) AV crossing using the pigtail/J-wire technique

Variable	Successful crossing	Failed crossing	*p* value
Ejection fraction (%)	49 ± 12	52 ± 11	0.21
LV impairment			0.16
None	47 (54.7%)	11 (78.6%)	
Mild	25 (29.1%)	1 (7.1%)	
Moderate	7 (8.1%)	2 (14.3%)	
Severe	7 (8.1%)	0 (0%)	
Mean gradient (mm Hg)	42 ± 6	45 ± 8	0.18
Classification of gradient			0.55
Low gradient	21 (24.4%)	3 (21.4%)	
High gradient	65 (75.6%)	11 (78.6%)	
Aortic valve area (cm^2)	0.75 ± 0.18	0.74 ± 0.12	0.77
Aortic annulus (mm)	24.2 ± 1.8	25.1 ± 1.8	0.10

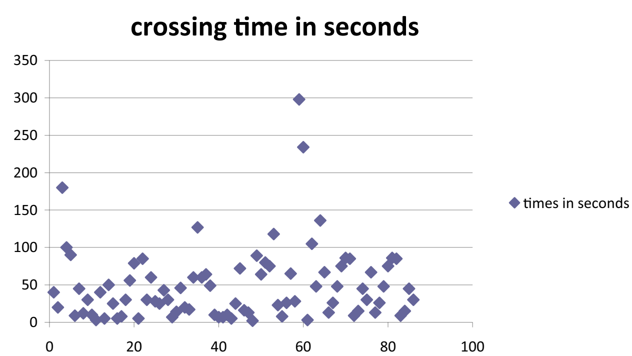

Fig. 2 Crossing times in 86 patients with successful employment of the pigtail/J-wire technique

tightly looped wire, once oriented more or less parallel to these edges, is more likely to be directed centrally, where the vertex of the loop easily finds its way through the slit-like opening. Similarly, it is the fine metal loop of a needle threader rather than the straight end of a thread that easily finds the needle's eye.

Reul et al. [2] and Ruparelia et al. [8] described the classic technique of crossing the aortic valve during TAVI with a left Amplatz® catheter and a soft straight-tip wire. However, quite often this technique is tidious and time-consuming. Once in the left ventricle, the Amplatz catheter needs to be exchanged for a pigtail catheter, which may result in loss of the wire position. For safety reasons, the straight wire has to be manipulated in the LAO view, which does not allow to judge on its anterior or posterior orientation. If there are no biplanar views available, it might be neccessary to repeatedly change the angle. Major complications potentially associated with the Amplatz®/straight wire technique include ostial dissection of the coronary arteries, hemopericardium and cerebral embolization [4–6]. On magnetic resonance, focal diffusion imaging abnormalities were found in 22% of patients undergoing retrograde crossing of the aortic valve [4]. Only 3% revealed clinically apparent neurological deficits. None of our patients presented with neurological symptoms. However, asymptomatic cerebrovascular events could not be excluded.

Kasel et al. [9] described another technique to cross stenotic aortic valves which is anatomically guided and involves the "Right Cusp Rule" [10]. Different from the conventional Amplatz®/straight wire technique, where the search for the valvular orifice is more or less based on trial and error, this approach relies on a systematic, anatomy-based concept. Still, it is a modification of the conventional Amplatz®/

straight wire technique, and most disadvantages and hazards discussed for that are in effect as well.

Limitations

There was already some experience with the pigtail/J-wire technique at our institution before initiating the present study. Thus, a less experienced operator may not obtain the same results right from the start. However, the technique is quite simple and easy to learn, so it is always worth to give it a try instead of getting stuck with the conventional approach. We did not randomly compare the Amplatz®/straight wire technique with the pigtail/J-wire technique to demonstrate superiority of one to the other. Instead, the goal was to demonstrate that a simple technique using atraumatic material already in place could successfully and safely be applied in the majority of patients, almost abolishing the need for more cumbersome maneuvers.

Conclusions

The pigtail/J-wire technique is simple, fast and safe. It does not require sophisticated material and it clearly works, as proven by the data presented here.

Clinical perspectives

Every interventionalist regularly applying current techniques for crossing stenotic aortic valves has experienced frustrations and complications. Given the potential of the inoffensive pigtail/J-wire approach, it makes sense to always give it a try before resorting to more tidious and hazardous approaches. This should particularly help to facilitate TAVI procedures.

Compliance with ethical standards

Conflict of interest None of the authors has to declare any potential conflict of interest with respect to this study, there are no relevant relationships with industry.

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