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CASE SERIES
Congenital heart disease

The rescue snared wire technique for challenging transcatheter pulmonary valve implantation: a case series of two patients

Giuseppe Tarantini [1*,†], Mauro Massussi [1,†], Luca Nai Fovino [1,‡], Domenico Sirico [2,‡], and Biagio Castaldi [2,‡]

[1]Department of Cardiac, Thoracic and Vascular Sciences, University of Padua Medical School, Via Giustiniani 2, 35128 Padua, Italy; and [2]Department of Women and Children's Health, University of Padua Medical School, Via Giustiniani 2, 35128 Padua, Italy

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Background Transcatheter pulmonary valve implantation (TPVI) is an effective treatment for right ventricular outflow tract (RVOT) dysfunction. Patients affected by congenital heart disease requiring TPVI may have difficult anatomies, thus making the intervention technically demanding.

Case summary We report a case series of two patients affected by RVOT dysfunction. Both the cases were characterized by difficulty to advance the valve over the wire, which was successfully overcome by the application of the snared wire technique (SWT) to TPVI.

Discussion Various technical pitfalls and tips have been described to facilitate the delivery of the transcatheter Edwards Sapien valve in the pulmonary position. The SWT described by the authors may be a helpful tool to gain supportiveness and stability of the guidewire during the procedure.

Keywords Structural heart intervention • Transcatheter pulmonary valve implantation • Snared wire technique • Congenital heart diseases • Case series

Learning points

- Transcatheter pulmonary valve implantation is an effective treatment and a valid alternative to surgery for patients suffering from right ventricular outflow tract dysfunction.
- Patients scheduled for percutaneous pulmonary valve implantation may have challenging anatomies requiring extensive manipulation of the delivery system in order to successfully deploy the bioprosthesis within the correct position.
- The snared wire technique represents an additional tool that may facilitate the delivery of a transcatheter heart valve in case of complex anatomies.

* Corresponding author. Tel: +39 049 8212309, Email: giuseppe.tarantini.1@gmail.com
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‡ The last three authors contributed to conception and design of the manuscript.
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Introduction

Transcatheter pulmonary valve implantation (TPVI), first performed by Bonhoeffer in 2000,[1] represents today a major advance in the interventional treatment of congenital heart diseases (CHDs). Right ventricular outflow tract (RVOT) dysfunction, with either regurgitation or stenosis, is a common sequela for a variety of complex CHDs (i.e. tetralogy of Fallot, pulmonary valve stenosis, truncus arteriosus, pulmonary atresia, etc.), who have undergone surgical repair or percutaneous intervention early in life. The recently published European Society of Cardiology (ESC) guidelines on the management of adult CHD recommend TPVI in symptomatic patients affected by severe pulmonary regurgitation (PR) and in asymptomatic patients as soon as the right ventricular end-systolic volume index exceeds 80 mL/m^2 and/or the right ventricular end-diastolic volume index (RVEDVi) exceeds 160 mL/m^2.[2]

In consideration of the relatively low risk of procedural complications, the main advantage of TPVI is to overcome the perioperative risk of redo cardiac surgery. However, although TPVI has been reported to be a feasible procedure with successful implantation rate greater than 95%, it remains a challenging and technical demanding procedure even for the experienced operator. In this report, we present two cases with complex RVOT anatomies in which TPVI resulted successful after the application of the snared wire technique (SWT).

Timeline

Case 1

Initial evaluation: female patient, heart surgery for pulmonary valve stenosis at the age of 6-year-old.

At the age of 62, the patient became symptomatic for worsening dyspnoea (NYHA II).

Outpatient evaluation: severe pulmonary regurgitation (PR) and right ventricular dilatation were diagnosed by transthoracic echocardiography (TTE) and cardiac magnetic resonance (CMR).

Elective admission for transcatheter pulmonary valve implantation (TPVI) procedure was scheduled.

Management: TPVI was challenging and successfully accomplished with the rescue snared wire technique (SWT).

In-hospital follow-up: TTE demonstrated normal function of the implanted bioprosthesis.

Discharged on day 3 after TPVI uneventfully.

Case 2

Initial evaluation: male patient, pulmonary balloon valvuloplasty at birth.

At the age of 15, the patient became symptomatic for reduced exercise tolerance.

Outpatient evaluation: free PR and severe right ventricular dilatation were diagnosed by TTE and CMR.

Heart team TPVI procedure was scheduled.

Management: elective hospital admission for coronary artery balloon compression test and pre-stenting of the right ventricular outflow tract with three CP stents.

Nine months later, elective TPVI was performed successfully thanks to the rescue SWT.

In-hospital follow-up: post-procedural TTE documented correct function of the implanted valve.

Discharged on day 2 after TPVI uneventfully.

Case presentation

Case 1

A 62-year-old Caucasian woman was referred to our institution due to RVOT dysfunction, severe PR, and right ventricular (RV) dilation as a result of prior surgical commissurotomy of congenital pulmonary valve stenosis (*Video 1A*). The patient was symptomatic for worsening dyspnoea and reduced exercise tolerance, she also complained palpitations as a consequence of paroxysmal atrial flutter. At cardiac physical examination, an early diastolic decrescendo murmur could be heard best at the left second intercostal space. The murmur increased with inspiration and S2 splitting was associated.

After functional and morphological outpatient, preliminary assessment of the RV volumes and RVOT anatomy (RVEDVi 162 mL/m^2, PR fraction 58%) through magnetic resonance imaging (MRI), the patient was scheduled for elective TPVI procedure (*Figure 1A–C*).

We secured right and left femoral vein accesses and left femoral artery access to implant an Edwards Sapien XT 29 mm (Edwards Lifescience, Irvine, CA, USA) transcatheter heart valve (THV). A Lunderquist Extra-Stiff guidewire was placed distally in the inferior lobar branch of the left pulmonary artery. The RVOT sizing with low pressure balloon inflation confirmed the presence of an adequate landing zone and the absence of coronary artery compression and aortic annulus distortion. The advancement of the delivery system within the pre-stented RVOT was challenging and during these manoeuvres, the optimal position of the guidewire was lost resulting in a lack of support to complete the deployment (*Figure 2A*, *Video 1B*). A 16-Fr Cook long-sheath was then introduced through the second

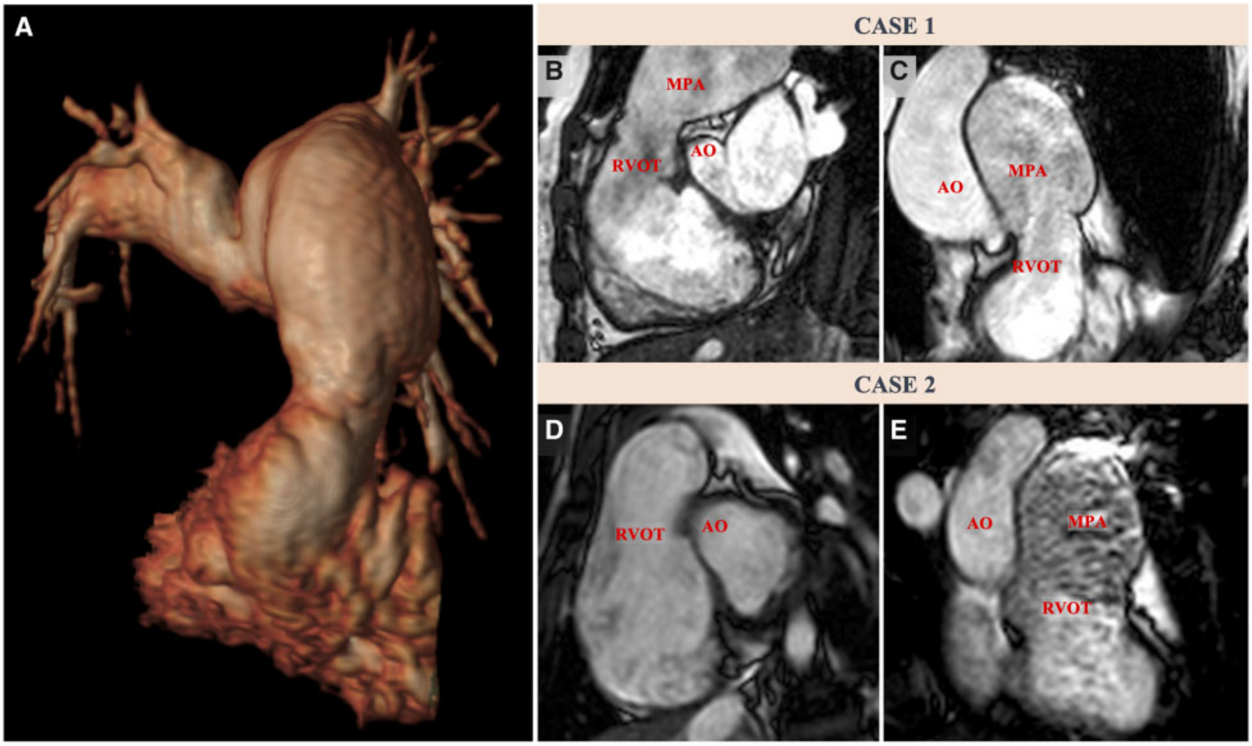


Figure 1 (*A*) *Case 1*: 3D-volume rendered image of right ventricular outflow tract, main pulmonary artery and its main branches. (*B* and *C*) *Case 1*: Right ventricular outflow tract assessment with cardiac magnetic resonance, sagittal and coronal views. (*D* and *E*) *Case 2*: Right ventricular outflow tract assessment with cardiac magnetic resonance, sagittal and coronal views. AO, aorta; MPA, main pulmonary artery; RVOT, right ventricular outflow tract.

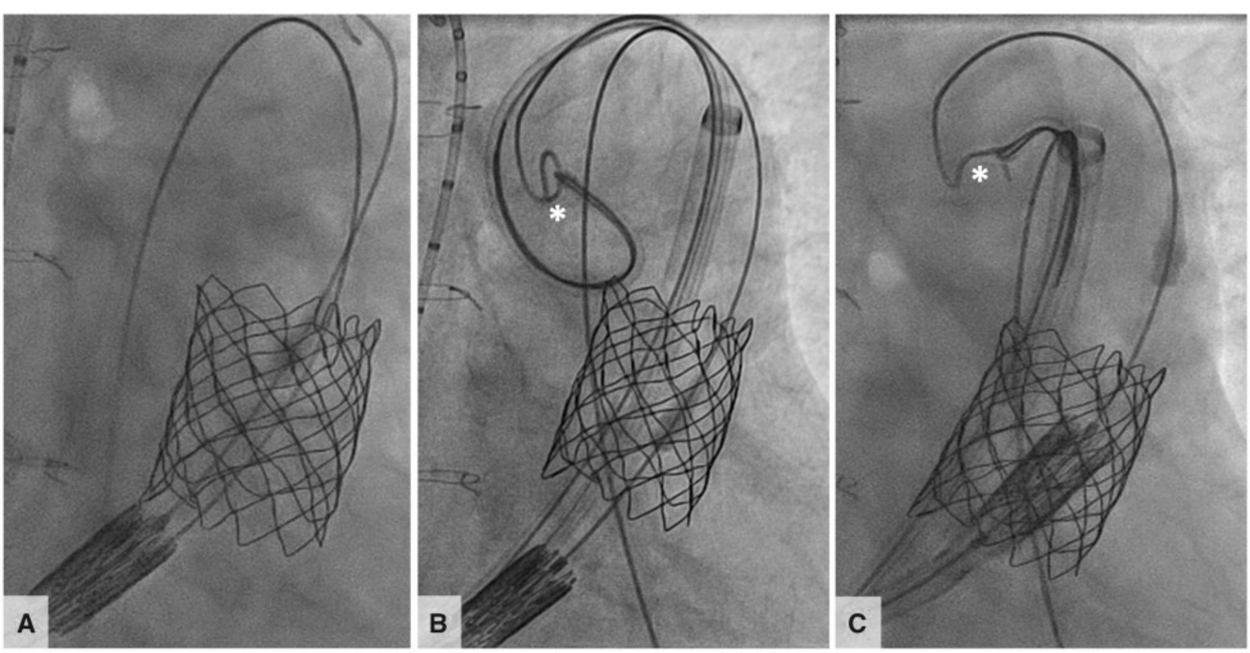


Figure 2 *Case 1*: angiographic images. (*A*) The difficulty encountered in the advancing of transcatheter heart valve over the delivery wire within the pre-stented right ventricular outflow tract. (*B*) The Gooseneck snare is advanced within the Cook long-sheath so as to snare (white asterisk) the Lunderquist guidewire. (*C*) Once the rail is created the transcatheter heart valve is advanced over the wire towards the proposed landing zone.

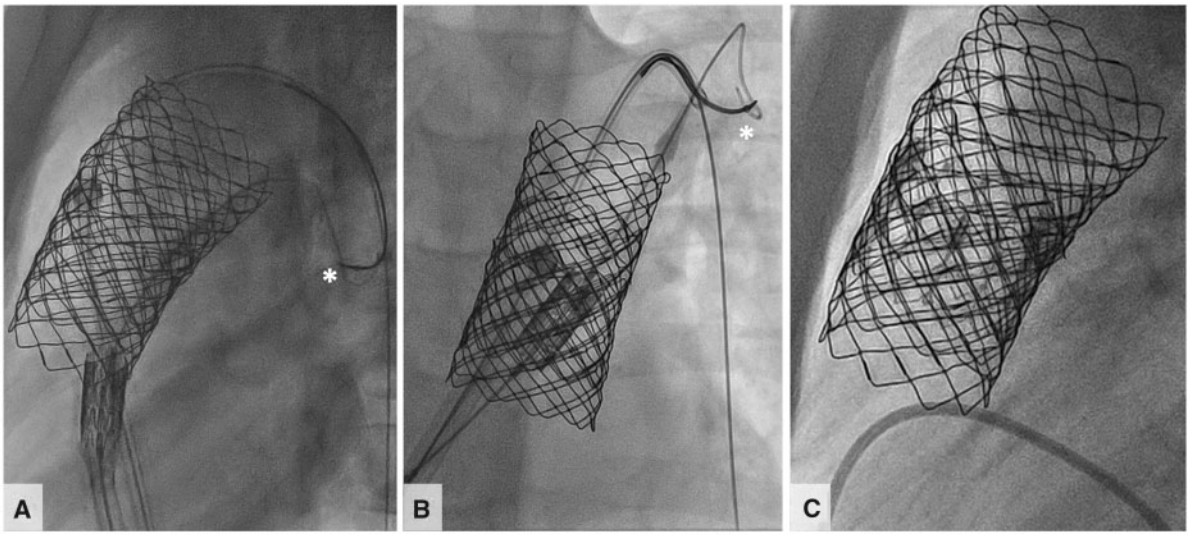


Figure 3 *Case 2*: angiographic images. (*A*) The veno-venous loop is established by advancing a Cook long-sheath and a Gooseneck snare in order to snare the Lunderquist guidewire (white asterisk). (*B*) The transcatheter heart valve is advanced over the stiff guidewire keeping a constant tension on the guidewire with a combination of pulling on the wire and pushing forward the sheath. (*C*) Final result, transcatheter heart valve deployed in the proposed landing zone.

venous access, a Gooseneck Snare (EV3 Inc., Plymouth, MN, USA) and a guiding catheter were advanced inside the long sheaths and the guidewire tip was snared and slightly pulled, creating a veno-venous rail inside the main pulmonary trunk, thus giving support to the delivery system, which was further advanced inside the pre-stented RVOT (*Figure 2B*, *Video 1C*). After removing the 16-Fr sheath and snaring catheter, the THV was deployed in the proposed landing zone with excellent angiographic result (*Figure 2C*).

The patient underwent a transthoracic echocardiogram (TTE), which assessed the correct function the THV and ruled out any peri-procedural tricuspid injury and she was discharged home uneventfully on the third post-operative day (*Video 1D*).

Case 2

A 15-year-old Caucasian boy with history of critical pulmonary stenosis and previous pulmonary valve balloon dilation at birth was referred to our Institution due to suspected RVOT dysfunction. The boy complained reduced exercise tolerance; thus, he underwent a TTE, which documented RV dilation and severe PR (*Video 2A*). Respiratory examination was normal, while a diastolic murmur was evident at cardiac physical examination. Thereafter, he underwent cardiac MRI, confirming RV dilation with severe PR (RVEDVi 167 mL/m^2, PR fraction 43%) and showing large RVOT (29 × 30 mm diameter) with short landing zone (*Figure 1D* and *E*). Although surgical approach was technically feasible, the heart team opted for transcatheter strategy considering the potential need for repeated high-risk cardiac surgery during patient's lifetime. Firstly, he was admitted for elective coronary artery balloon compression test and pre-stenting of the RVOT with three CP stents. After 9 months, the patient was admitted for elective TPVI procedure. As in the previous case, we secured femoral vein access from both side and proceeded to implant a 29 mm Edwards Sapien XT THV. A Lunderquist Extra-Stiff

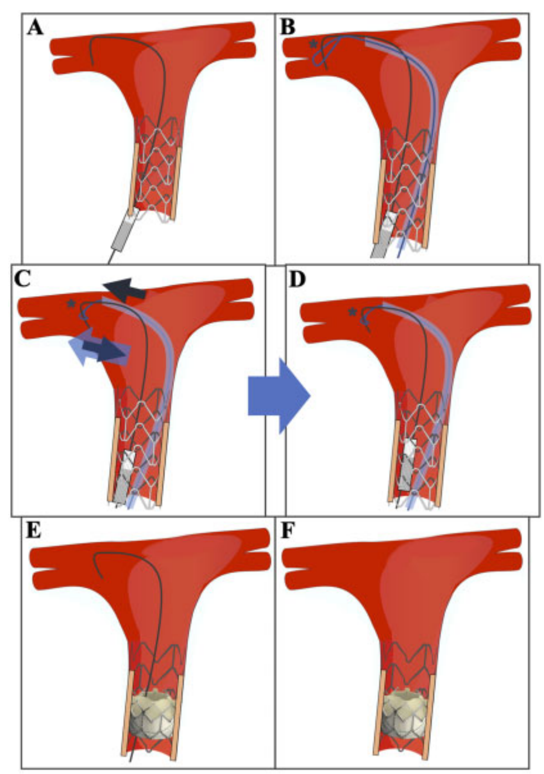
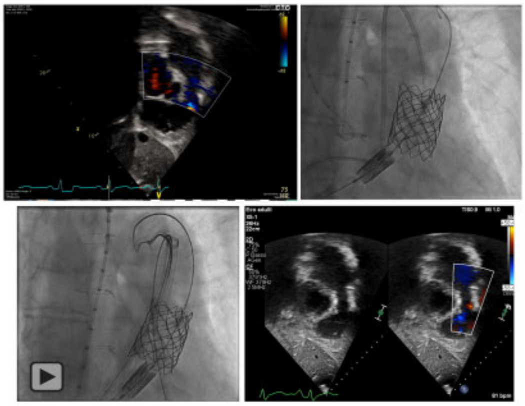


Figure 4 The snared wire technique applied to transcatheter pulmonary valve implantation. (*A*) Difficulty in advancing the transcatheter heart valve over the delivery wire within the pre-stented right ventricular outflow tract. (*B*) Advancement of the 16-Fr Cook long-sheath to snare (asterisk) the guidewire. (*C* and *D*) *Push and pull* strategy (blue arrows) to advance the transcatheter heart valve over the wire. (*E*) The deployment of the transcatheter heart valve in the landing zone. (*F*) Final result after the removal of the guidewire.



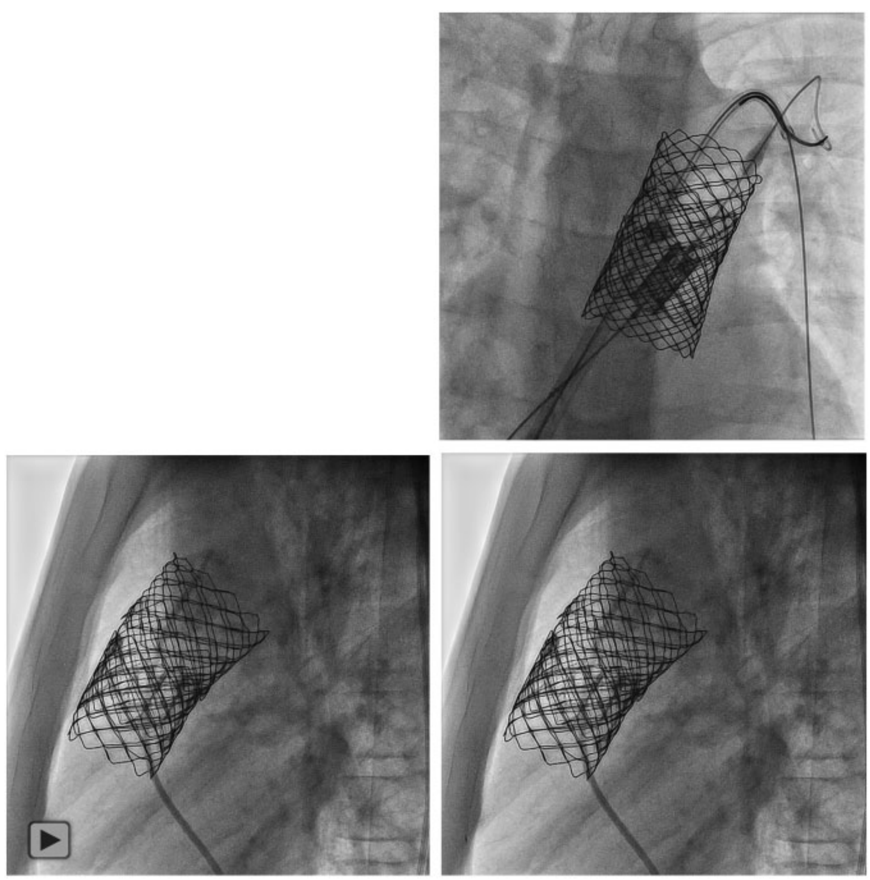
Video 1 (*A*) Case 1, transthoracic echocardiography showing pre-procedural severe pulmonary regurgitation. Subcostal right anterior oblique view. (*B*) Case 1, the difficulty encountered in the advancing of transcatheter heart valve over the wire. (*C*) Case 1, the snared wire technique to successfully advance the transcatheter heart valve towards the landing zone. (*D*) Case 1, post-procedural transthoracic echocardiography documenting normal function of pulmonary transcatheter heart valve. Subcostal right anterior oblique view.

guidewire was placed distally in the inferior lobar branch of the left pulmonary artery. The trackability of the delivery system within the pre-stented RVOT was poor and the position of the guidewire was lost while advancing the THV. Again, we introduced the 16-Fr Cook long-sheath through the second venous access and we snared the guidewire by the use of a Gooseneck Snare and a guiding catheter (*Figure 3A* and *B*, *Video 2B*). By slightly pulling the veno-venous rail, we were able to advance the THV inside the main pulmonary trunk leading to a successful deployment in the proposed landing zone (*Figure 3C*, *Video 2C*).

Again, a post-procedural TTE documented the normal function of the pulmonary THV and ruled out any tricuspid injury (*Video 2D*). The patient had an uneventful postprocedural course and he was discharged from the hospital 2 days on the second postoperative day.

Discussion

TPVI is a safe and effective option for the treatment of pulmonary valve dysfunction with a successful implantation rate greater than 96% and a procedural mortality rate of about 1,5% if performed in well-trained cath labs.[3] Early and late-onset complications can



Video 2 (*A*) Case 2, transthoracic echocardiography showing pre-procedural severe pulmonary regurgitation. Enlarged main pulmonary artery and RVOT can be appreciated. Parasternal short-axis view. (*B*) Case 2, the snared wire technique. (*C*) Case 2, final angiographic result. (*D*) Case 2, post-procedural transthoracic echocardiography documenting normal function of pulmonary transcatheter heart valve. Parasternal short-axis view.

occur after TPVI procedures. Among the former ones, coronary artery compression (1.3%) by the stent or by the THV and partial or total conduit rupture (4.1%) are the most serious, followed by THV migration and access site-related complications. Overall, TPVI failure occurs in about 3% of cases due to acute complications often requiring surgical conversion. Among late-onset complications, infective endocarditis and stent fractures are reported in literature.[3]

The candidates for TPVI are mainly either adolescent or adult patient with RVOT dysfunction. The alterations occurring within the RVOT and the main pulmonary artery after paediatric heart surgery frequently make the positioning of a THV a technically demanding intervention with the hardest part being the advancing of the mounted THV over the wire towards the landing zone. During these critical steps, even extra stiff wires may not adequately support the valve delivery. When the position of the guidewire is lost or the delivering of the THV is troublesome, the adoption of the rescue SWT may provide an adequate rail to allow the appropriate deployment of the THV. When performing the SWT, the advancing of the THV over the Lunderquist wire is obtained keeping a constant tension on the guidewire with a combination of pulling on the wire, holding firmly the snare against the sheath and slightly pushing forward the Mullins sheath (*Figure 4*, *Videos 1* and 2). The increased support derived from the presence of the Mullins sheath itself (*buddy introducer*) is helpful, but not sufficient to reduce the friction of the valve against the RVOT stent previously implanted. Together these manoeuvres allow the disengagement and step up of the THV in the preferred location. While a conceptually similar snare technique has been previously described as a potential tip during troublesome crossing of surgical aortic valves with a THV,[4] Maschietto *et al.*[5] recently, and independently from our Institution, described the SWT by showing the results of 21 patients, who underwent a successful TPVI with this novel manoeuvre. The authors reported three cases of tricuspid valve injuries, all occurred in the rescue SWT group while none of the patients of the planned SWT group experienced any tricuspid valve injury, thus probably due to the extensive manipulation of the delivery system before adopting the SWT. Notably, Hascoët *et al.*[6] recently described a modified procedure for TPVI with the use of a large delivery sheath to protect tricuspid valve from mechanical injuries.

Conclusion

The snaring wire technique we applied in the described cases, represents a useful procedural tool and may support interventionists to overcome the pitfalls of TPVI in very complex RVOT anatomies.

Lead author biography

Professor Giuseppe Tarantini is the Director of the Interventional Cardiology Unit in Padua University Hospital, Padua, Italy. He graduated from the University of Parma School of Medicine in 1997 and completed his residency training at the University of Padua in 2001. Prof Tarantini performs both coronary and structural interventional cardiology procedures with a special interest in Transcatheter Aortic Valve Implantation (TAVI). He is the President of the Italian Society of Interventional Cardiology-GISE and he is the chair of the EAPCI scientific documents and initiatives commitee. He authored more than 430 peer review papers and several books.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case series including images and associated text has been obtained from the patients in line with COPE guidance.

Conflict of interest: G.T. is a proctor for Boston Scientific and has received lecture fees from Edwards Lifesciences and Medtronic. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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