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Use of a Microcatheter in a Telescopic System to Reach Difficult Targets in Complex Congenital Heart Disease

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Background: Some lesions can be very difficult to reach, especially if acute angles and/or multiple turns "protect" access. Once reached, the guiding system needs to give sufficient support for balloons or stents to be deployed. Methods: A "telescopic" system was created consisting of: (1) a microcatheter with guidewire. This system fits into any catheter allowing a 0.035 inch wire. (2) a 4Fr "delivery" catheter. (3) If sharp angles were encountered, the 4Fr catheter was deployed through a 6Fr or larger angulated guiding sheath. This was cut-off 15 cm out of the groin and re-valvulated with a standard short introducer sheath. Patients and results: Since 2004, 89 microcatheter telescopic systems were used during a 4-year period in 1,225 procedures (7.3%). The technique allowed probing with a floppy steerable and exchangeable guidewire, securing any gained position as well as exchanges with a stiffer guide wire if required. Procedures where the telescopic system was effective included: complex stenoses *e.g.* aortopulmonary collaterals (n = 21), tortuous ducts (n = 9), anterograde balloon dilation of critical aortic stenosis (n = 8) and crossing Blalock Taussig shunts (n = 3). Once in place, the telescopic system allowed delivery of embolic material (n = 38), balloon angioplasty (n = 21), stent deployment (n = 23), fulguration of pulmonary valve (n = 1) or introduction of medication (n = 1). The interventionalists felt that using the telescopic system had reduced fluoroscopy and procedure time. Conclusions: The microcatheter-telescopic system is an invaluable tool to reach difficult targets and allows exchange for suitable guidewires permitting balloons, stents, embolisation material or radiofrequency energy to be deployed in such targets. This approach has become our standard when dealing with difficult targets protected by a tortuous route.

Key words: percutaneous intervention; microcatheter; co-axial system; telescopic; Progreat®

INTRODUCTION

Diagnostic and interventional catheterizations have become technically more demanding. Some of the target lesions are difficult to reach due to anatomical factors, for example: multiple twists and turns which protect access to the lesion, or when a small vessel takes off at an acute angle from a big pulsatile vessel. Similarly, once the target is reached, the guiding system needs to give adequate support for balloons or stents to be deployed. Standard commercially available catheters are frequently unable to reach such targets and, once reached, give inadequate support and stabilization to perform complex procedures. We learned to use a microcatheter in a telescopic system which helped significantly in these difficult situations. This study was undertaken to evaluate our experience with this technique.

MATERIALS AND METHODS

Microcatheter systems (*e.g.* Progreat™, Terumo Europe N.V., Leuven, Belgium) are 2.7Fr–3.0Fr kink-resistible catheters with or without radiopaque marker bands at the distal tips, available in different lengths (110–130 cm). Most come with highly steerable hydrophilic guidewires longer than the microcatheter. This

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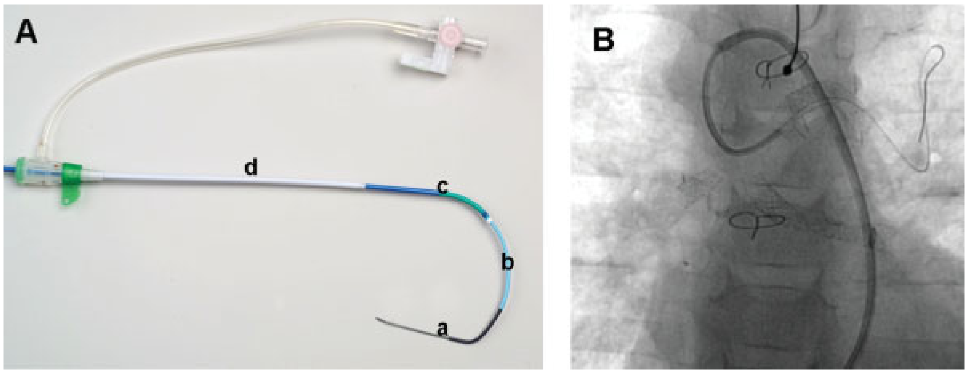

Fig. 1. A–B: A: Telescopic system: 0.014 in. guidewire-microcatheter (a); 4F cobra catheter (b); 6F cut-off guiding sheath (c); (revalvulated with a 6F introducer sheath—(d)). B: Telescopic system to enter a central shunt originating from the ascending aorta at an acute angle; a stent has been delivered through the guiding sheath. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

system fits into any catheter that allows a standard 0.035-inch wire.

In order to be launched at an appropriate angle, the microcatheter was usually passed through a 4 French (Fr) ''delivery'' catheter (*e.g*. right coronary, cobra or mammary artery catheter). If the initial angle was very acute and more than 90°, the 4 Fr catheter was deployed *via* a 6 Fr or larger right coronary or mammary artery guiding catheter/sheath. The latter acts as stabilization, and may double as an angiographic catheter or long delivery sheath for subsequent balloon angioplasty or stent placement if necessary. Because of the length of the catheters and the design of the co-axial system, it was often necessary to cut off the guiding sheath about 15 cm distal to the groin in order to allow an adequate distance for manipulation of the shorter 4Fr catheter or delivery of balloons and stents on shorter shafts. In order to reduce bleeding and allow contrast injections if required, the cut-off guiding sheath was usually re-valvulated by placing a conventional short 6Fr introducer sheath (or other size as required by the sheath Fr size) at the distal end of the guiding catheter (Fig. 1).

During the approach and certainly once the target was reached, both the microcatheter and 4Fr catheters were advanced as far as possible; the soft guiding wire of the microcatheter then replaced by a stiffer 0.014 or 0.018 inch wire through the microcatheter or a stiff 0.035 inch wire through the 4Fr catheter if required. In the latter case, the combination of microcather-coronary-guidewire is used as a single unit similar to a guidewire in order to facilitate distal advancement of the 4 Fr catheter. Frequently four to five experienced and synchronized hands were needed to reach the targets with the desired apparatus.

TABLE I. Cardiac Diagnosis and Target Vessels

	Number (*n*)	%
Diagnosis		
Univentricular heart disease	38	52
Tetralogy PA-VSD	16	22
Aortic valvular stenosis	8	11
DORV	2	3
Scimitar syndrome	2	3
Coronary artery fistula	2	3
Coarctation of aorta	1	1
Other	4	5
Target vessels		
Aortico-pulmonary collaterals (all variants)	47	52
Tortuous PDA	9	11
Veno-venous collaterals	8	9
Aortic valve	8	9
Vena cavae	3	3
Blalock-Taussig shunt	3	3
Coronary artery fistula	2	2
PuV	2	2
Left or right main branch pulmonary artery	2	2
Coarctation, aorta	2	2
Septal defects	2	2
Other	3	3

Abbreviations: PA-VSD, pulmonary atresia with ventricular septal defect; DORV, double outlet right ventricle; PDA, patent ductus arteriosus; PuV, pulmonary valve.

RESULTS

Since 2004, the microcatheter telescopic system was used during a 4-year period in 89 of the 1,225 (7.3%) interventional catheterizations performed. Five patients were referred after multiple attempts using conventional catheters failed. The co-axial system was used once in 62 patients and 27 times in 11 patients as an element of entirely separate procedures. The median age and weight at catheterization was 2.5 years

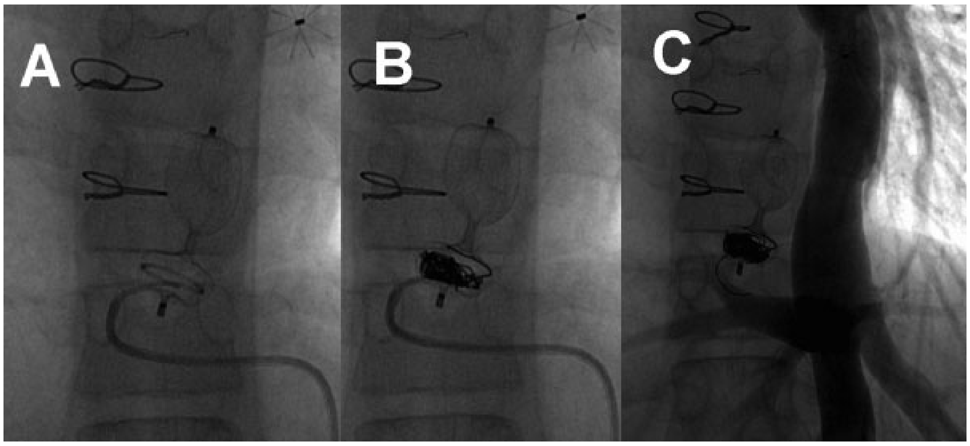

Fig. 2. A–C: An ASD Amplatzer had been positioned in a large intrahepatic fistula after Fontan operation. significant residual shunt persisted. (A) A microcatheter was pushed through a 5F end-hole catheter into the Amplatzer device to deliver microcoils (B) in order to obtain complete occlusion (C).

(newborn–36.2 years) and 12.1 kg (1.0–72.5 kg), respectively.

The system was most frequently used in patients with univentricular cardiac malformations (52%) and Tetralogy-Pulmonary atresia with ventricular septal defect complexes (25%). Some patients had rare conditions such as mid-aortic syndrome with renal artery stenosis or obstruction of the vena cava. A detailed list of primary diagnoses in the patients can be viewed in Table I. At the time of the procedure 140 surgical procedures and 163 percutaneous interventions had already been performed prior to catheterization in 55 and 48 patients, respectively. In the group with univentricular pathology, 55% had a Fontan circuit and 26% a bidirectional Glenn type shunt. The target vessels and structures are summarized in Table I. In some children there were multiple target vessels and in one patient the system was used to penetrate the right atrial disc of an Amplatzer device (AGA Medical Corporation, Plymouth, MN, USA) placed in a hepatic fistula in a patient with a Fontan conduit (Fig. 2).

A total of 96 procedures were performed using the microcatheter telescopic system. Details are summarized in Table II. Embolisation usually consisted of coil placement (ordinary as well as microcoils) and in one patient, micro-embolisation particles (Embopshere®, BioSphere medical, Rockland, MA) were used. The disc of an Amplatzer device was filled with coils to occlude a residual shunt. Fifteen embolisation procedures (37% of embolisations) were performed for collaterals arising from the mammary artery. Balloon angioplasty was most commonly performed for neonatal critical valvular aortic stenosis (8/18 = 44%) and stenosis in aortic-pulmonary collaterals (8/18 = 44%). Nineteen stents were placed, 42% (8/19 = 42%) for stenosis in aortic-pulmonary collaterals and 42% (8/19 = 42%) in the ductus arteriosus.

TABLE II. Procedures

	Number (n)	%
Embolization	41	43
Stent deployment	19	20
Balloon angioplasty	18	19
Diagnostic angiography	8	8
Recanalization	2	2
Facilitate device placement	2	2
Fulgeration pulmonary valve	1	1
Delivery medication	1	1
Planned procedure impossible	4	4

The system was very effective to cross tortuous ducts and enabled the placement of eight ductal stents, after the ductus had been straightened by passing a coronary guidewire through the microcatheter positioned in a distal branch of the pulmonary artery (Fig. 3). The microcatheter was also used to cross the aortic valve anterogradely for balloon angioplasty in eight neonates with critical aortic valve stenosis (Fig. 4) and in one with a critical pulmonary valve stenosis. The floppy guidewire made it easy to safely curl the soft catheter in the left ventricular apex and the interventionalists felt that it cut down significantly on manipulation of catheters and duration of the procedures. In one patient the telescopic system was used to retrograde perforate the pulmonary valve (Fig. 5). A 2.5 kg premature infant presented with pulmonary atresia, imperforate pulmonary valve and an enormously dilated right ventricle due to massive tricuspid regurgitation. It was impossible to obtain a stable position underneath the pulmonary valve in order to allow fulguration. A retrograde approach was attempted. However, the duct originated from the aorta at an acute angle. We there-

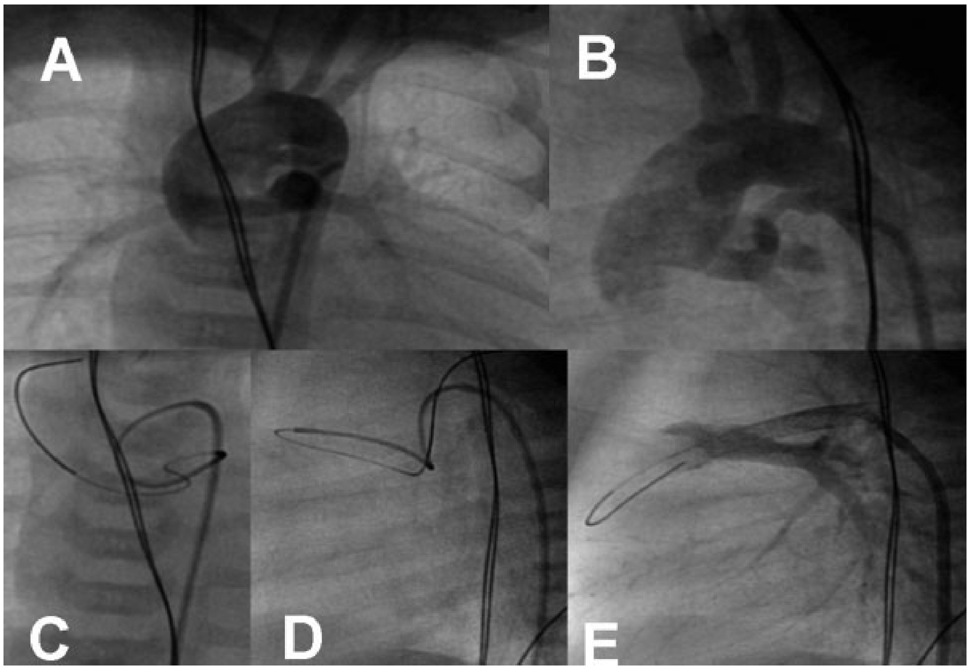

Fig. 3. A–E: Aortogram showing a complex tortuous duct in a patient with pulmonary atresia—VSD (A: antero-posterior view; B: profile): the duct has a sharp take-off from the aorta, with a cumulated angulation > 360°. 5F mammary guiding sheath in aorta, probing the duct using the microcatheter with a 0.014 in. coronary wire (C: antero-posterior view; D: profile); E: deployment of 3.5-mm stent.

fore chose to deploy the telescopic system. A 4-Fr mammary diagnostic catheter was placed close to the origin of the duct and the telescopic system advanced until the microcatheter was just above the pulmonary valve. A coronary guidewire with proven electrical conductance (personal experience) (PT2^{TM}, Boston Scientific, Natick, MA, US) was placed and the pulmonary valve perforated with standard radiofrequency energy (20 J for 3 sec) with the coronary wire entering the right ventricle outflow tract. The wire was then advanced into the right atrium, snared and a veno-arterial loop was created. The pulmonary valve was subsequently dilated anterogradely from the femoral vein.

The median fluoroscopy time for all procedures was 26.5 min (range: 7.0–97.0 min). A total of 51 additional procedures were also performed during the same session.

In four instances (4%), the system failed to reach the objective. In two cases, the microcatheter and guidewires could not traverse a stent previously placed at a sharp angle, in the same patient on two separate occasions – it kept going through the lateral cells of the stent. In another patient, the system allowed good and stable guidewire position, but the angle was so acute (>270°) that the angioplasty balloon could not traverse the sharp turn of the vessel. In the fourth patient the microcatheter-0.014 inch guidewire combination was used as a guidewire to facilitate placement of a 9 F sheath distally into the pulmonary artery; failure was because of insufficient support of the system at the transition right atrium-right ventricle – a jugular approach was successful.

DISCUSSION

This study shows that the microcatheter co-axial telescopic system is a valuable addition to the armamentarium of the interventional pediatric cardiologist. The system is effective and has proven to be an invaluable tool to reach difficult target lesions: allowing exchange of wires and sheaths in order to place stents and balloons safely and effectively for angioplasty, coils for embolisation as well as assistance in diagnostic procedures. It has a high rate of success. This is illustrated by the success achieved in the 5 patients referred with stenosis of aortic-pulmonary collaterals after multiple failed attempts at other centers.

Using the co-axial telescopic system allows adequate stability to cross angled and tortuous vessels. This is evidenced by the fact that the majority of procedures occurred in patients with univentricular and Tetralogy-type circulations. Both of these are renowned for their difficult to reach and angulated collateral vessels (veno-venous collaterals and aortic-pulmonary collaterals). It is therefore understandable that balloon angio-

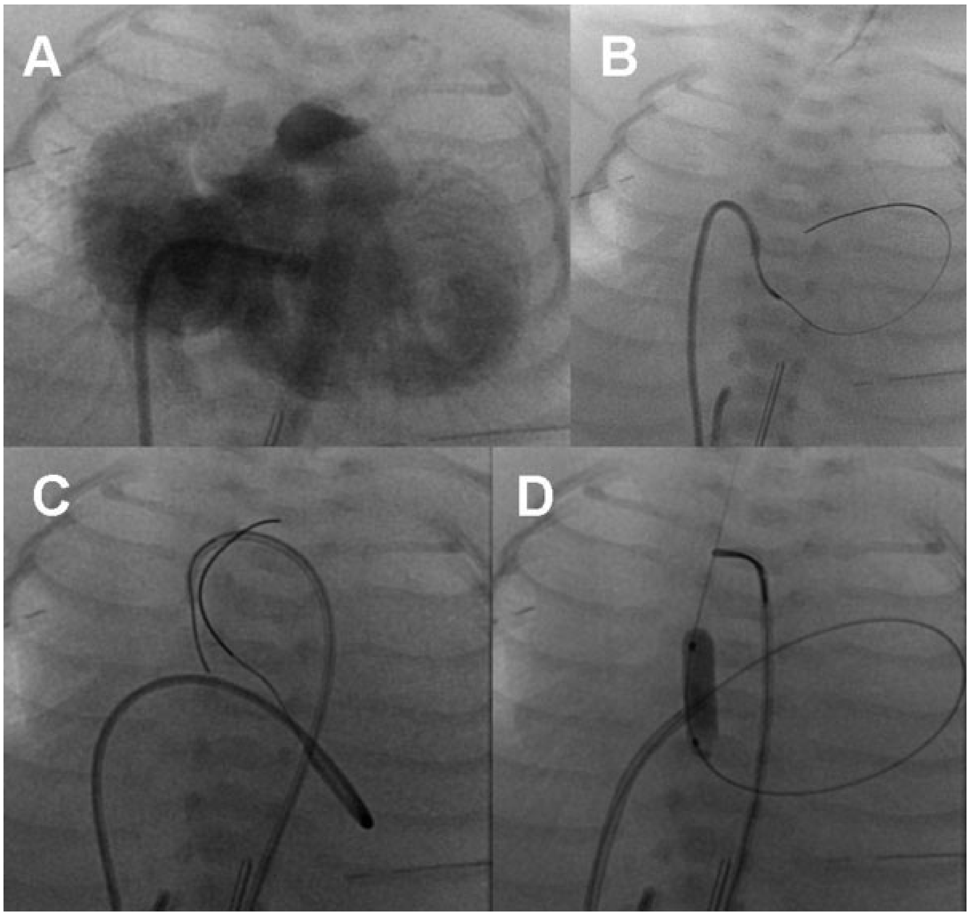

Fig. 4. A–D: Neonate with critical aortic stenosis. A: Left atrial angiogram showing the anatomic landmarks with a dilated left ventricle. B: Through a 4F mammary catheter positioned in the left atrium, a microcatheter is advanced through the mitral valve; the aortic valve is probed with the 0.018 in. glidewire. C: Glidewire in ascending aorta. D: The glidewire is exchanged for a 0.014 in. coronary wire; the 4F catheter is exchanged for a 5F right coronary guiding wire; the coronary wire is snared in the ascending aorta to give support. A 5-mm coronary balloon is inflated across the aortic valve.

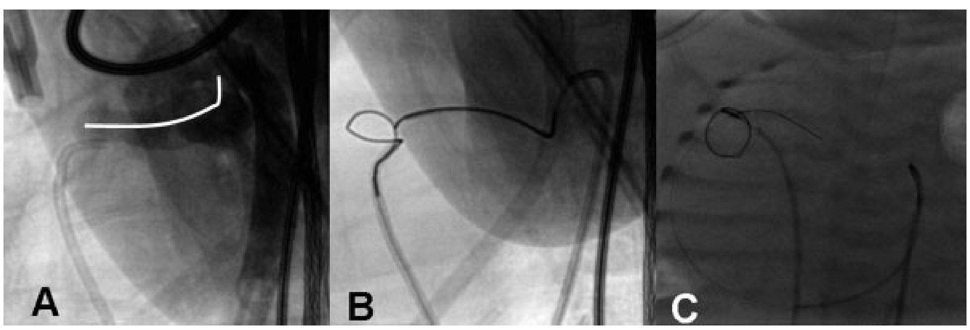

Fig. 5. A–C. Retrograde fulguration of the pulmonary valve. A: Aortogram lateral view: the duct (white line) takes off at a sharp angle from the transverse thoracic aorta; B: the duct is probed *via* a 4F-mammary catheter with a Progreat microcatheter, with a 0.014 in. PT2 conducting coronary wire extruding a few millimeters in order to deliver radiofrequency energy locally; 5 mm snare in the right ventricular outflow tract acting as target. C: after crossing the pulmonary valve, the coronary wire is snared in the right atrium to make a veno-arterial rail.

plasty/stenting and embolisations make up the majority of procedures performed using this system. The large number of stents also demonstrates that the system is not only able to reach obscure target lesions, but also give sufficient support to deliver stents at the site of obstruction. A handy extra of using a microcatheter is the fact that microcoils and liquid embolisation material can easily be delivered using the microcatheter, as evidenced in some of our patients. Also, radiofrequency energy can safely be delivered: a Progreat® catheter gave adequate insulation over the length of the wire, concentrating the radiofrequency energy at the tip in the patient in whom fulgeration of the pulmonary valve was performed.

The system also holds advantages for balloon angioplasty of critical neonatal aortic and pulmonary valve stenosis. All aortic stenoses were crossed anterogradely *via* the foramen and left ventricle. In one premature infant the same technique was used during a bail-out procedure to cross anterogradely and stent retrogradely a critical neonatal coarctation. Our clinical impression was that using the microcatheter co-axial system and guidewire not only made the procedures technically easier and cut down on fluoroscopy time, but also gave less dysrrhythmias when manipulated in the left ventricle. Safety has also been shown in other publications using a microcatheter system [1,2]. Stenting of the patent arterial duct was made easier and safer by using the system to cross tortuous and angled ducts. We usually positioned an angled catheter such as a 4 Fr right coronary at the aortic end of the duct and then carefully advanced the microcatheter into a distal pulmonary artery branch. Once in position, the glidewire was exchanged for a 0.014 inch or similar guidewire to deliver the stent.

The system is also valuable for diagnostic work, especially to advance diagnostic catheters through narrow or obscure pathways. In one patient it was used to cross a ventricular septal defect and in another to guide the diagnostic catheter through a fenestration in a Fontan circuit. We found it helpful to traverse angulated modified Blalock-Taussig shunts or central shunts arising from a dilated aorta.

On a practical note, we used a technique called ''trackability'' to advance the microcatheter through tortuous vessels or *via* the left ventricle to the aorta: it simply means that the microcatheter follows its guidewire when advanced forward slowly, and then, by recapturing the guidewire and advancing the catheter, the target is reached [3]. In addition, if the microcatheter needs to be withdrawn over a coronary guidewire, an extension wire (*e.g*. DOC® Guidant Corporation, Santa Clara, CA, US) on the coronary wire is useful in order to safely and efficiently exchange the microcatheter. Alternatively, the microcatheter can be cut off the guidewire section by section whilst being withdrawn.

A disadvantage of the microcatheter system is the difficulty of de-airing. Once the target is reached and the wire is withdrawn, it may be difficult to de-air the lumen of the microcatheter; however, the priming volume of the catheter is limited (unprimed = 0.55 ml; after being flushed and upon removal of guidewire = 0.35ml). It is also important for patients to be adequately anticoagulated and the lumen should frequently be flushed with heparinised saline, as the lumen may easily thrombose during the procedure. Another limitation is the inability to inject adequate volumes for angiography. This can be partly counteracted by doing hand injections with a relatively small syringe (10 cc) filled with mildly diluted contrast – best results are obtained doing the angiograms in apnea and review it using subtraction. The microcatheter itself is also not adequate for pressure measurements, although some microcather (3F) systems have given acceptable pressure tracings [4].

Early in our experience, we always first attempted to reach the target with standard catheters and conventional guidewires. As our experience grew, we shall now soon reach for a telescopic system.

CONCLUSIONS

This technique has made some ''impossible'' targets reachable in a stable, safe and efficient way. The microcatheter telescopic system has become an invaluable tool in order to reach difficult targets, and to exchange for adequate guide-wires allowing balloons, stents, embolisation material or radiofrequency energy to be deployed in such targets. This approach has become our standard practice when dealing with difficult targets protected by a tortuous route.

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