Case reports
Pulmonary artery stenting without angiographic imaging

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Pulmonary artery stenosis is a frequent complication seen after surgical repair of tetralogy of Fallot. In this setting, endovascular stent implantation is now accepted as the first-choice therapeutic option. However, angiographic imaging still being held as mandatory to check the stent position before final deployment, this procedure is not considered suitable for patients who cannot be submitted to angiography. In this paper, we report a novel method for the correct implantation of an endovascular stent without angiographic imaging. A 9-year-old boy underwent cardiac catheterization to relieve a severe left pulmonary artery stenosis. A previous attempt had been aborted due to a life-threatening anaphylactic reaction to the contrast medium. To avoid angiography, a contrast medium-filled compliant atrial septal defect sizing balloon (Amplatzer Sizing Balloon, AGA Medical Corporation) was used to image the vessel stenosis and successfully guide stent deployment. After the procedure, the transstenotic pressure gradient disappeared and the left-to-right pulmonary perfusion imbalance almost completely reverted.

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Introduction

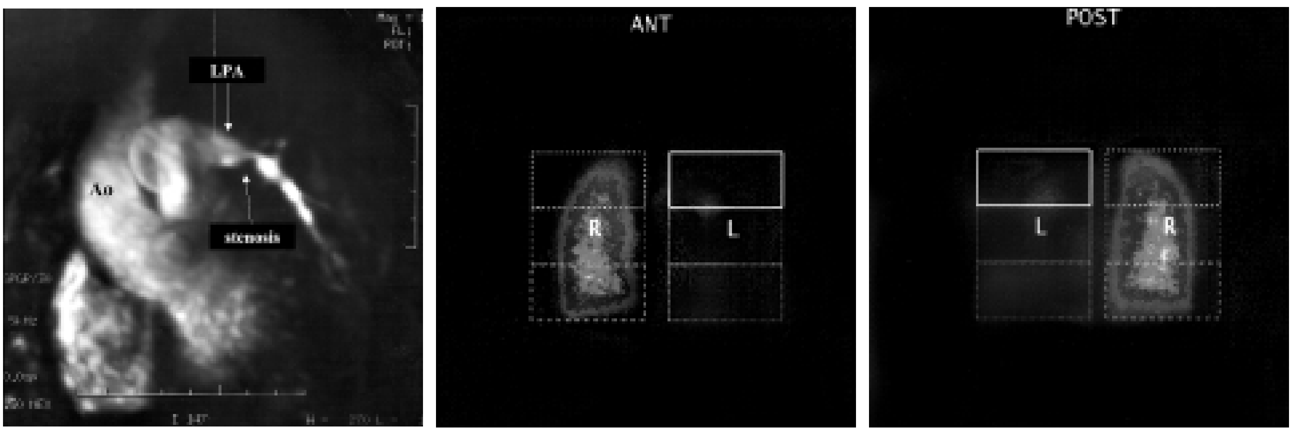
Pulmonary artery (PA) stenosis is a frequently seen long-term complication of surgically repaired tetralogy of Fallot. It may be native in origin, due to an underestimated PA “coarctation” consequent to closure of the ductus arteriosus[1], or related to previous shunt procedures[2,3]. The percutaneous approach is now worldwide accepted as the first-choice therapeutic option for this kind of vascular obstruction[3-8], with endovascular stent implantation being considered safer and more effective than balloon angioplasty in achieving a long-lasting relief of stenosis[9,10]. An essential step in the stenting procedure is a detailed anatomic evaluation of the stenotic vessel, in order to select a stent of suitable size and length. Non-invasive techniques allow accurate imaging of the severity and extent of the PA narrowing before the interventional procedure[11,12]. However, a critical premise for stent deployment is the on-line precise outlining of the stenotic vessel during the stenting procedure itself. Nowadays, in spite of technological advances in materials and refinements of the stenting procedure[13], angiographic imaging is still considered mandatory to achieve an accurate stent positioning before final deployment. Thus, this therapeutic option is not considered suitable for patients who cannot be submitted to angiography. In this paper, we report on a novel method for the correct implantation of an endovascular stent without angiographic imaging.

Case report

A 9-year-old boy with tetralogy of Fallot, submitted to a left modified Blalock-Taussig shunt procedure at the age of 8 days and to complete repair at the age of 19 months, underwent cardiac catheterization at our Institution to relieve a severe left PA stenosis. An attempt to treat the vascular obstruction had already been performed elsewhere a few years before. However, due to a life-threatening anaphylactic shock to the contrast medium, requiring massive drug support as well as a prolonged period of mechanical ventilation, the percutaneous intervention had been aborted. Hence, it was decided to follow up the patient, postponing surgical treatment of the stenosis when the patient became symptomatic. At the time of our observation, the patient was in NYHA class II-III and at clinical examination showed a 2-3/6 systolic murmur widely irradiated over the chest. Chest X-ray imaged significant cardiomegaly, with right-to-left imbalance of the pulmonary vascular markings. At echocardiography, the right cardiac chambers were severely dilated and the right ventricle showed a moderate functional impairment and a high systolic pressure, as inferred from the presence of tricuspid valve regurgitation. At Doppler analysis, a peak pressure gradient of 50 mmHg with diastolic run-off was recorded across the left PA. In order to avoid surgery, a second, non-angiographic-imaged, attempt of percutaneous relief of the vascular obstruction was planned. Thus, the PA anatomy and physiology were investigated at magnetic resonance imaging and lung perfusion scanning, respectively. Magnetic resonance imaging showed the presence of a 12 mm-long severe stenosis of the mid-segment of the left PA, with a minimal diameter of 2.5 mm (Fig. 1A). It resulted in almost complete absence of the left lung perfusion (left lung 7%, right lung/left lung perfusion ratio 13.3:1) as evaluated at perfusion scanning (Fig. 1B). Cardiac catheterization confirmed the presence of right ventricular hypertension (right ventricular pressure 48/0-16 mmHg; right ventricle/left ventricle pressure ratio 0.5) and left PA stenosis (peak-to-peak pressure gradient 36 mmHg). In order to precisely image the vascular obstruction before stent implantation, a compliant 45 mm long atrial septal defect sizing balloon (Amplatzer Sizing Balloon, AGA Medical Corporation) was inflated with contrast medium inside the left PA. This approach essentially confirmed the magnetic resonance imaging findings in terms of the severity and length of the stenotic segment, and also allowed precise delineation of the site of the stenosis and the size of the pulmonary branch downstream from the obstruction (Fig. 2A). This picture was then recorded on the angiographic guiding screen, allowing us to position a 28 mm long Jomed stent that was successfully dilated to 10 mm (Fig. 2B). After stent deployment, the pressure gradient completely disappeared, with a significant decrease in RV pressure overload (final right ventricle/left ventricle pressure ratio 0.38). The fluoroscopic time was 12 min. Follow-up spiral computed tomographic scan and lung perfusion scintigraphy confirmed the significant increase in the vessel size (final diameter 8.5 mm), with a concurrent improvement of the left-to-right lung perfusion imbalance (left lung perfusion 32%, right lung/left lung perfusion ratio 2.1:1) (Fig. 3).

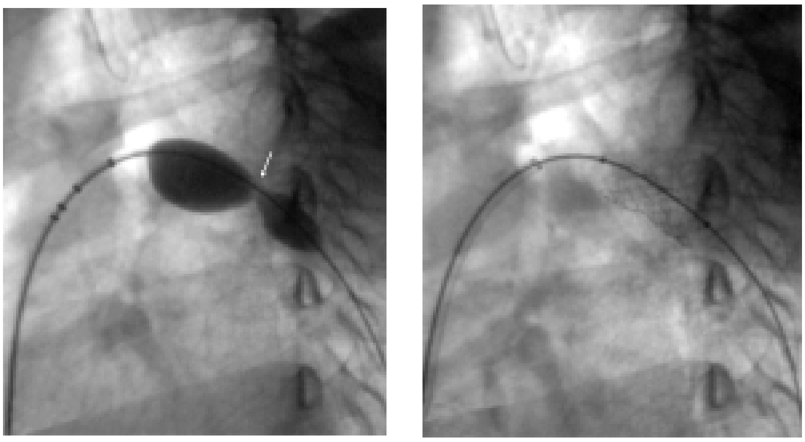
Discussion

PA stenosis is frequently diagnosed in patients with surgically repaired tetralogy of Fallot. It may be native in origin, being more commonly found on the side of the ductus arteriosus[1] and underestimated at the time of corrective surgery. More often, it is consequent to previous shunt procedures, being reported in 14-30% of palliated patients and caused by inappropriate surgical techniques, increased intimal proliferation or PA kinking[2,3]. Over time, the percutaneous approach proved to be easier, safer and more effective than surgery in relieving both native and iatrogenic PA obstructions[3-8]. In this setting, several studies showed that balloon-expandable endovascular stent implantation was significantly more effective and long-lasting than balloon angioplasty[9,10]. Recent advances in stent profiling and technical modifications of the stenting procedure improved the results of this therapeutic option, rendering it possible to treat even critically ill or small patients[13]. However, the mainstay of any stenting procedure remains the precise selection of the prosthesis, as well as its correct positioning before balloon inflation. While the former step may be guided by pre-procedural imaging techniques[11,12], on-line angiography is still considered mandatory for correct positioning of the stent across the stenosis. Thus, the rare patient who cannot be submitted to angiography is not considered as a candidate for stenting procedures and for these patients balloon angioplasty is the only possible non-surgical



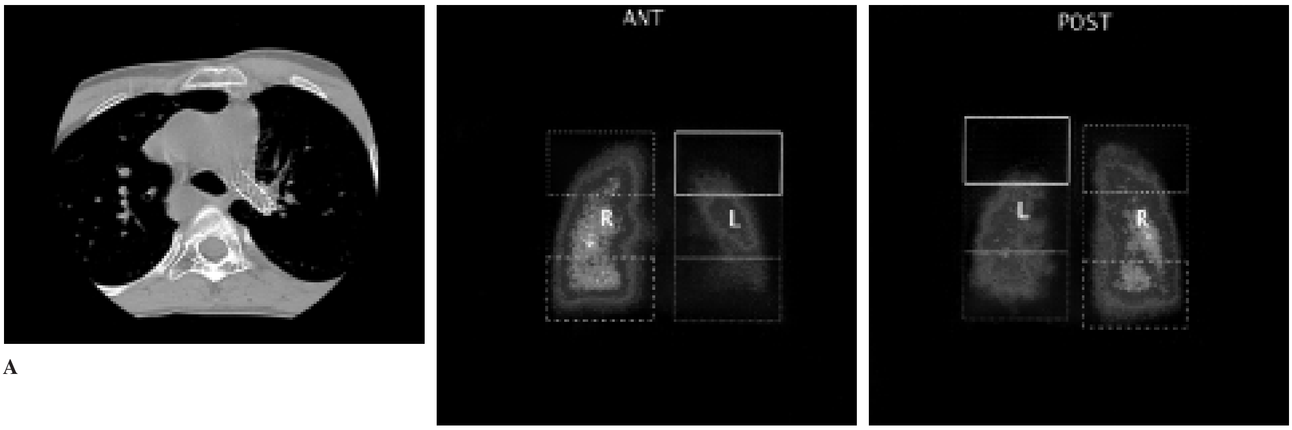
A B

Figure 1. *Pre-procedure magnetic resonance imaging showing a severe left pulmonary artery (LPA) stenosis* (A)*, resulting in an almost complete lack of left lung (L) perfusion at scintigraphy* (B). *ANT = anterior view; POST = posterior view; R = right lung.*



A B

Figure 2. *At cardiac catheterization* (A)*, the contrast medium-filled compliant atrial septal defect sizing balloon perfectly delineates the vessel stenosis* (white arrow), *so guiding the stent deployment* (B).



A

B

Figure 3. *Post-procedure spiral computed tomographic scan* (A) *and lung perfusion scan* (B) *showing a significant increase in both the left pulmonary artery diameter and left lung (L) perfusion. ANT = anterior view; POST = posterior view; R = right lung.*

option. Although it has been reported that the use of a compliant sizing balloon could reliably size up the stenotic vessels[14], to our knowledge this is the first report of stent implantation completely guided by this novel approach. Ideally, this challenging problem may be worked out using intravascular ultrasound (IVUS) techniques that enable both imaging of the vessel and quantification of the stenosis by Doppler analysis. To date, this approach has been reported only in experimental models of IVUS-guided angioplasty using transballoon ultrasound techniques[15]. However, IVUS-guided stenting is theoretically much less feasible than balloon angioplasty, due to the "noise" resulting from the metallic prosthesis. Thus, in our opinion, it could be very challenging and time-consuming to guide stent positioning and deployment with this approach. Conversely, the use of a compliant atrial septal defect sizing balloon enables quick on-line imaging of the site, severity and extent of a vessel stenosis without angiography, thus easily guiding the stenting procedure. In this patient, the non-invasive diagnostic work-up allowed us to accurately understand in advance the vessel anatomy and the hemodynamic impact of the stenosis. At cardiac catheterization, the use of the sizing balloon enabled us not only to precisely locate and measure the narrowest point of the stenotic vessel just before stent positioning, but also to "image" the vessel size downstream from the stenosis, so as not to oversize the final stent diameter.

In conclusion, this method proved highly effective in quickly guiding stent positioning across the vessel stenosis before balloon inflation and, hopefully, it may be safely used in all patients who are unsuitable for an angiographic-guided stenting procedure and who would hence be candidates for balloon angioplasty or surgery.

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