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Brief Report

Use of a cutting balloon catheter to dilate resistant stenoses in major aortic-to-pulmonary collateral arteries

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Abstract We report the successful use of a cutting-balloon catheter in dilating stenoses in major systemic-to-pulmonary collateral arteries which had been resistant to high pressure balloons. After dilation using the cutting balloon, we implanted stents to produce a marked improvement in both pulmonary blood flow and arterial saturation. The technique provides useful palliation for patients having such stenotic collateral arteries.

Keywords: Tetralogy with pulmonary atresia; interventional catheterisation

THE TREATMENT OF PATIENTS WITH TETRALOGY of Fallot with pulmonary atresia with small or absent central pulmonary arteries, and flow to the lungs through systemic-to-pulmonary collateral arteries, remains challenging. Options involving unifocalization, and aiming at complete repair, have recently been performed with reasonable results.[1,2] These surgical approaches, nonetheless, are not possible in every patient. Because of pronounced hypoplasia of the collateral arteries, some patients prove unsuitable for surgical unfocalization. Furthermore, in some patients, progressive cyanosis may develop during growth as the stenoses become progressively greater within the collateral arteries, further diminishing the supply of blood to the lungs. These often severely stenotic collateral arteries can be very difficult to treat using conventional balloons and/or stenting techniques. When we analysed our data, we found that about one-sixth of all lesions could not be dilated using conventional high pressure balloons.[3]

Recently, the cutting balloon[4] was introduced as an alternative technique to dilate stenoses in coronary arteries resistant to high pressure balloons. When such a balloon is inflated, three small blades unfold, making small incisions in the intimal and medial layers of the artery. The subsequent remodelling of the vessel inhibits the development of restenosis. The first results in patients with coronary arterial disease are promising. The technique has not yet been used in patients with congenital heart disease. This reported case illustrates its potential use in our field.

Case report

An 8-year-old boy was followed in our centre with tetralogy of Fallot with pulmonary atresia, ventricular septal defect, and absent central pulmonary arteries. Flow of blood to the lungs is dependent on the presence of multiple collateral arteries arising from the descending aorta. Because of poor perfusion of the left lung, and severe stenoses on the various collateral arteries supplying both lungs, the boy was deeply cyanotic, with a resting saturation of no more than 70%, and had poor exercise tolerance. As his anatomy precluded total repair, or even palliation with a surgical shunt, percutaneous intervention had been attempted using high pressure balloons in 1995 and 1997. Some of the stenoses proved resistant to pressures up to 25 atmospheres (Fig. 1a). At that time, therefore, further intervention was considered futile. In the years following this procedure, the boy became progressively cyanotic, with resting saturations of 67–70%. This was associated with decreasing exercise tolerance and invalidating headaches. We therefore attempted intervention using the cutting balloon.

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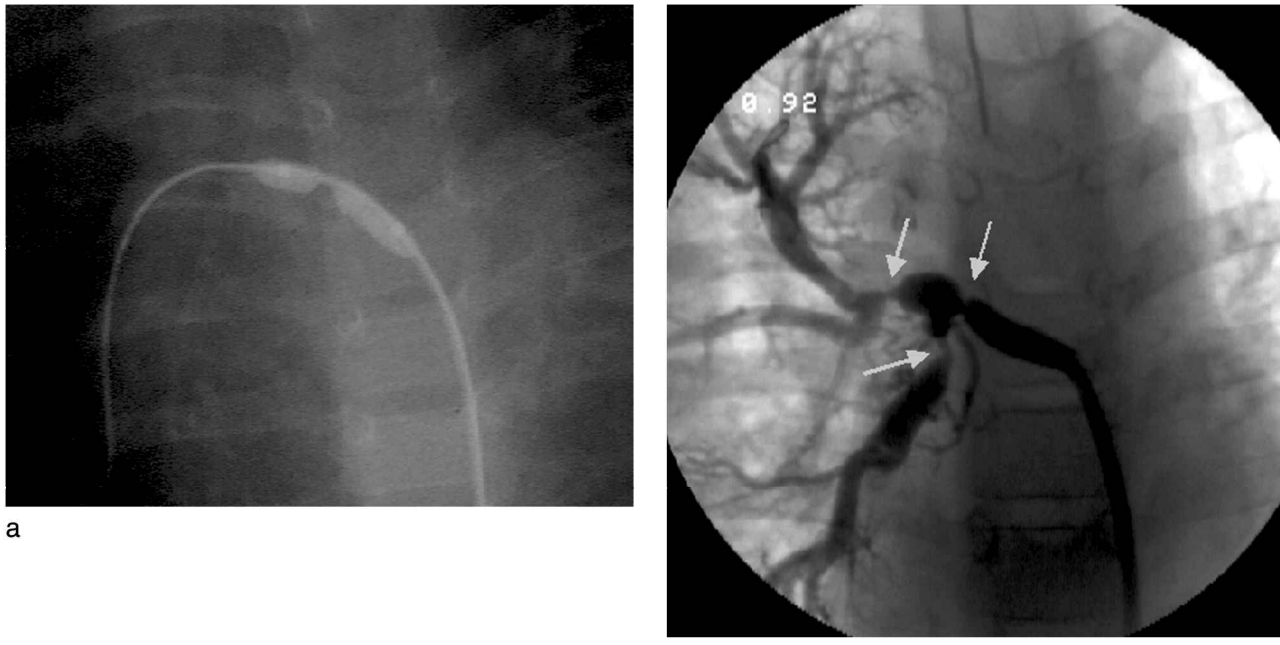

Figure 1.
Attempted ballon dialation (a) of a collateral artery performed in 1997. During this dilation, the ballon was insufflated up to 25 atmospheres. Despite this extreme high pressure the waist did not disappear. The angiogram (b) shows another collateral visualized at this time with 2 stenoses on the branches to the upper segments, and one stenosis on the lower branch (arrows).

During the first procedure, we dilated a collateral dividing into two branches, with the first supplying segments of the right upper lung and the second supplying segments of the right lower lung. Two important stenoses were seen in the first branch, while one severe proximal stenosis was found along the second branch (Fig. 1a). To make sure the vessel wall was thick enough to allow the expansion of a 3.5 mm cutting balloon, we first performed intravascular ultrasound. This showed medial thickening at the site of the stenoses sufficient to permit safe inflation of the cutting balloon. The entire procedure was performed through a 6 French guiding catheter (Guidant Veripath) using 0.014 inch coronary guide wires. First, we inflated a 3.5 mm cutting balloon in the proximal and distal stenoses found along the upper branch. In contrast to the previous procedures, the cutting balloon expanded to its nominal size with an inflating pressure of 4 atmospheres (Fig. 2a). Angiography showed some improvement, but important recoil at the site of the stenosis (Fig. 2b). Further dilation was performed with a 4 mm cutting balloon. Subsequently, the branch to the lower lobe was selectively catheterised and the proximal narrowing was dilated using the same 4 mm cutting balloon. Because of residual and significant narrowing, a 4.5/15 mm coronary stent (Guidant Ultra) was implanted in the upper branch, and afterwards a 5/18 mm peripheral stent (Guidant Herculink) was deployed in the branch to the lower lobe. These stents were deployed without any problem and nicely opened up the vessels. A "kissing balloon" technique was used to open the stents, which were in T-position (Fig. 2c). This resulted in a marked improvement of flow through both collateral arteries, with significant increase in percutaneous saturations from 65% to 82%. This also increased his exercise capacity, with disappearance of the headaches. During a second procedure performed 3 months later, angiography of the dilated collateral arteries demonstrated perfect patency of both stents (Fig. 2d). During the same procedure, a second collateral to the right lower lobe was treated in a similar way, with an optimal result and further increase in arterial saturation.

Discussion

The treatment of patients with tetralogy of Fallot and pulmonary atresia, with flow to the lungs through systemic-to-pulmonary collateral arteries, has changed dramatically during the last decade. Encouraging results have been reported with either multistage or single-stage unifocalization leading to complete repair. Not all patients, however, are suitable candidates for these new approaches. Those patients are sometimes palliated with shunts, or are even left untreated. An important problem associated with systemic-to-pulmonary collateral arteries

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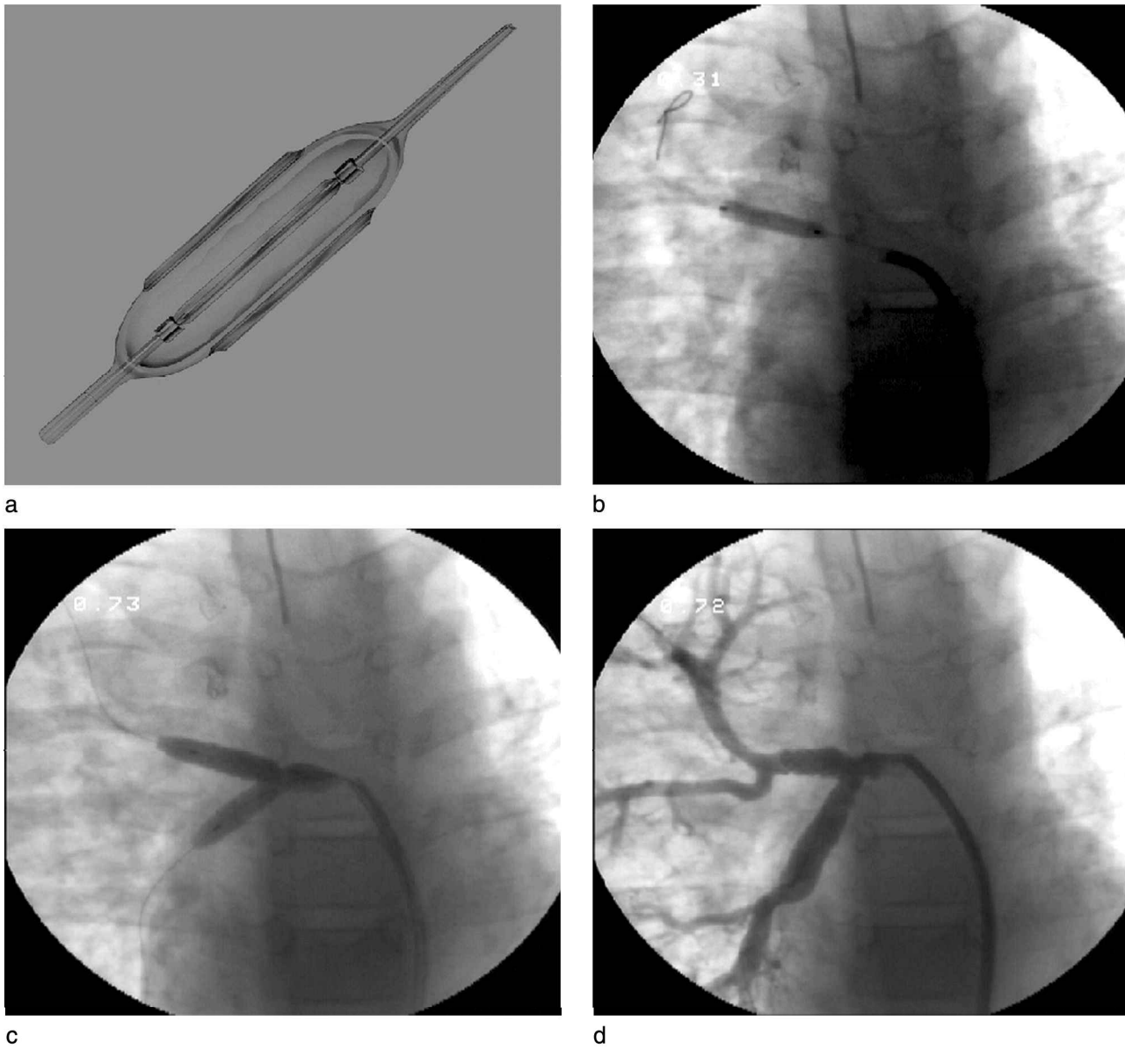

Figure 2.
The cutting balloon (a) is a balloon with 3 implanted atherotomes each 0.177 mm thick. It was placed (b) in the branch to the upper lobe. The "kissing balloon" technique (c) was used to deliver stents, with the final result (d) showing nicely patent vessels with improved perfusion to the pulmonary parenchyma.

is that these vessels have a high tendency to develop severe stenoses during growth, leading to hypoperfusion or even loss of lung segments and systemic hypoxemia. This often leads to severe and debilitating cyanosis in untreated or palliated patients. For these patients, interventional catheterisations can be performed to treat the stenoses.[3,5,6] The results of these interventions are variable. In the majority of patients, acceptable results can be obtained by simple balloon dilation with or without stenting. In our experience, nonetheless, it proved impossible to dilate the stenoses using high-pressure balloons in one-sixth of our patients. If the lesion is not dilatable, stenting is no longer a good option, as the stent will not open the vessel. Alternative methods, such as rotational ablation, have been reported with good success.[7] This technique mechanically removes the obstruction.

In our patient, we used a cutting balloon as an alternative technique. Three small artherotomes each 0.177 mm thick are implanted on this balloon. When the balloon is folded, these "knives" are retracted into the plastic, preventing accidental damage to the vessels. When inflated, the atherotomes cause small incisions into the intima and media of the stenosis. In coronary arteries, this allows remodelling, with

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possibly a decreased risk for restenosis. For lesions which are difficult to dilate using conventional or even high-pressure balloons, such as stent restenosis, the cutting balloon is an alternative option for treatment. If there is important recoil, subsequent stenting is possible in lesions which would otherwise have been difficult to treat.

In our patient, the cutting balloon was used to treat stenoses on systemic-to-pulmonary collateral arteries with an excellent result. We used the balloon to treat lesions which had proven resistant to high pressure noncompliant balloons during previous interventions. With the blade balloon, the lesions opened easily and could successfully be stented. This dramatically improved the clinical condition of this severely cyanotic young boy. Before using the balloon, we checked the thickness of the vessel wall using intravascular ultrasound. In the narrowest parts of the vessel, the mural thickness was markedly increased, which probably corresponds with the medial thickening known to be found at the sites of stenosis. We feel the technique to be safe provided a balloon of suitable size is selected.

This technique has other potential applications in congenital cardiac disease. It could be used in the treatment of severe peripheral pulmonary arterial stenosis after unifocalization procedures, or in patients with multiple native severe peripheral pulmonary arterial stenoses. The percutaneous fenestration of a patch in the atrial septum after the Fontan operation can similarly be facilitated with a cutting balloon. The present limitation is that the balloons are designed for coronary interventions, and thus are no larger than 4 mm. Larger balloons would be useful in our practice, but it is doubtful whether they will be developed.

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