Interventional pediatric cardiology: state of the art and future perspective

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Abstract Interventional catheter therapy has drastically changed the practice of cardiac catheterization and the treatment of congenital heart disease. In some centers, interventions amount to 30% or more of all cardiac catheterizations. For some lesions, surgery has become obsolete. For valvular pulmonary stenosis, balloon dilatation is the therapy of choice and results in permanent elimination of pressure gradients. Balloon dilatation is also indicated for valvular aortic stenosis and results in mild residual stenosis with gradients below 35 mmHg. Aortic insufficiency, mostly mild, is induced in 15%-20%. Native and post-operative coarctation can be successfully dilated. About 50% of pulmonary artery stenoses can be relieved by balloon dilatation. Stent placement increases the success rate to 75%-80%. Stent implantation is also being investigated for other lesions. Valvular pulmonary atresia can be opened by catheter technique. In the majority of patients over 6 kg, the patent ductus arteriosus is transcatheterly closed by implantation of the Rashkind occluder. Secundum or similar atrial septal defects and muscular ventricular septal defects can also be closed by catheter technique, but suitable specific occluders are not generally available at present. Therapeutic vascular occlusions, radiofrequency ablation of aberrant conduction pathways and arrhythmia foci are examples of other catheter interventions.

Key words Congenital heart disease • Catheter intervention Balloon angioplasty • Balloon valvuloplasty • Catheter occlusion

Abbreviation PDA patent ductus arteriosus

The treatment of congenital heart disease has changed dramatically over the past years: surgical options have been vastly expanded to the most complex lesions and to correction in the newborn period, and several “simple” lesions can now be corrected by catheter technique without surgery. Currently, in 33% of patients the indication for cardiac catheterization is interventional therapy. About 10 years ago, this development was initiated by the success of percutaneous coronary angioplasty. Dilatation of the pulmonary and aortic valve, aortic coarctation and pulmonary arteries was quickly and widely accepted after the first reports in 1981-1983. The mechanism of balloon dilatation was shown to be a controlled longitudinal tear of the vascular wall extending into the media [3] or, in balloon valvuloplasty, a tear of fused valvular commissures [43]. Non-surgical umbrella occlusion of the patent ductus arteriosus was developed and modified over the years to the current standard. Therapeutic closure of pathologic vessels, intra- or extracardiac defects is performed by placement of specific permanent implants. After initial thrombus formation the implant is embedded in connective tissue and endothelialized.
Balloon dilatation of pulmonary arteries

Of all lesions, 50%–60% can be dilated successfully with a restenosis rate of 16%–17% [13, 33]. In some cases, restenosis is caused by elastic recoil of the stenotic wall segment. Implantation of metal lattice vascular endoprostheses, so-called stents, can overcome this recoil and improve success rate to 70%–80%. The complication rate of pulmonary artery dilatation is 5%–11% [8, 13, 14, 33] with about 2% mortality [14].

Miscellaneous vascular balloon dilatations

In cyanotic lesions, aortopulmonary collaterals and surgical shunts can be dilated to improve oxygenation with limited success. Stent implantation can be beneficial in some cases.

Balloon dilatation and stent placement do not improve overall outcome in congenital pulmonary vein stenosis. Most peripheral arterial and especially post-operative stenoses can be successfully dilated.

Balloon dilatation of aortic coarctation

Balloon dilatation of post-operative coarctation has become the treatment of choice (Fig. 1) with a success rate of 80%–90% and residual pressure gradients below 15 mmHg [10, 34]. So far, restenosis has been observed in 3% [34].

Native coarctation can also be dilated effectively with a success rate of 80% and similar gradient reduction [36, 41]. However, the restenosis rate was up to 25% within 6 years [36] and even higher in newborns and young infants. The ideal age for balloon dilatation of coarctation appears to be 2–8 years. In young adults, the procedure bears an increased risk of aortic dissection [7].

Overall complication rate is 6%–10% [8, 10], mostly consisting of femoral artery occlusions. The mortality is about 1%–2% [10, 41]. Late aneurysm formation was observed in about 10%. Regular follow-up preferably with MRI is therefore warranted.

Balloon dilatation of the pulmonary valve

Balloon dilatation of the pulmonary valve is the standard therapy for all age groups including newborns. Pressure gradients are usually reduced below 25 mmHg [28, 39, 44]. Transient reactive infundibular stenosis occurs in approximately 20% of patients. Follow-up over 8 years has documented persistent elimination of the stenosis [17, 19]. Severely dysplastic valves, however, require surgical excision in most cases.

Complications have been encountered in about 5% of the dilatations [8, 39] mostly as femoral or iliac vein occlusions. Mortality is below 0.5%. For all age groups, morbidity and mortality both compare favorably with the respective surgical results. In Tetralogy of Fallot and other more complex cyanotic lesions, dilatation of the pulmonary valve can replace shunt surgery in most newborns and young infants [26].