Interventional cardiology

Over the last 15 years the treatment of congenital heart defects has changed from being primarily surgical to a combination of interventional cardiology and surgery. Although interventional cardiology has replaced surgery for a number of defects, it has also provided an additional and complementary treatment to surgery for many conditions.

The cardiovascular system can be viewed as a pump with attached blood vessels. Major ‘replumbing’ such as the arterial switch operation for transposition of the great arteries remains the province of the surgeon, while dilations and occlusions are increasingly performed in the cardiac catheterisation laboratory. The heart also has an electrical system that may be disturbed by pacemaker failure, ventricular tachycardia, or unwanted electrical circuits and interventional electrophysiology is now an important part of interventional cardiology.

Dilations

Dilations are among the commonest interventional cardiology procedures and stenoses of all structures and blood vessels have been subjected to dilation. Balloon atrial septostomy was introduced by Rashkind and Miller over 30 years ago and remains in use in its original form to improve mixing in patients with transposition physiology. Older patients have a good response to balloon dilatation. However in aneurysm formation, dilation of pulmonary artery stenoses either native or acquired is useful in a percentage of patients. Vessel recoil and the risk of over-dilatation of distal tapering pulmonary arteries limits the clinical usefulness of pulmonary artery angioplasty. These problems have been addressed by the introduction of endovascular stents which were developed to treat peripheral vascular disease in adults. Stents are usually expanded by a balloon into a lattice-like structure that lines and supports the vessel wall.

This has been a particularly important development for many postoperative and some preoperative patients with pulmonary artery stenoses in which the results of surgical reoperation can be disappointing. Implantation of stents can be technically challenging and may require further dilation to allow for growth if implanted in younger children. The stents usually develop a neointima which can be excessive, if the stent is not fully dilated throughout its length, and result in restenosis. Nevertheless the increase in vessel diameter produced by stents is significantly greater than that usually produced by angioplasty. Stents have also been used to successfully treat native coarctation in older patients, baffle stenoses in patients after a Mustard operation, and stenotic collateral arteries in patients without true central pulmonary arteries.

Medical manipulation of the arterial duct transformed the management of neonates in the late 1970s. Angioplasty of the arterial duct has been used for the rare duct dependent patient who fails to respond to prostaglandin infusions. Stents have also been used to maintain ducal patency in patients with hypoplastic left heart syndrome or pulmonary atresia. However restenosis of the relatively
small stent in patients with pulmonary atresia, in whom the stented duct is the sole pulmonary blood supply, may have grave clinical consequences. We have reserved stent implantation in the duct for patients who have an additional source of pulmonary blood supply, such as patients with hypoplastic right ventricles in whom a critically atretic or stenotic pulmonary valve has been dilated, but whose right ventricle is not yet large enough to provide the entire pulmonary circulation.

Oclusions
Surgery for congenital heart defects started with ligation of the arterial duct, and likewise transcatheter occlusion of the arterial duct was the first transcatheter occlusion to be performed. Porstmann et al developed an Ivalon plug which was pushed into the duct over a guidewire. This procedure had a high occlusion rate and low embolisation rate but could only be used in children over 5 years of age. Rashkind and Cuaso developed a hooked single umbrella and later a double umbrella for arterial duct occlusion. The double umbrella was widely employed in the late 1980s and early 1990s but was found to have an unacceptably high (20%) incidence of residual shunts requiring implantation of a second and even third devices and was judged not to be as cost effective as surgery. The use of spring coils (single or multiple) for duct occlusion has reversed the cost effectiveness argument in favour of transcatheter occlusion. Occlusion of septal defects has been more difficult and a wide range of double disk devices has been developed. Their main drawback has been the requirement for adequate tissue margins around the defect to achieve occlusion without the device impinging on nearby valves. The surgeon under direct visualisation can stitch a patch in place with little or no margin. Despite these limitations over a thousand patients worldwide have had a trial septal occlusion. Porstmann et al developed an Ivalon plug which was pushed into the duct over a guidewire. This procedure had a high occlusion rate and low embolisation rate but could only be used in children over 5 years of age. Rashkind and Cuaso developed a hooked single umbrella and later a double umbrella for arterial duct occlusion. The double umbrella was widely employed in the late 1980s and early 1990s but was found to have an unacceptably high (20%) incidence of residual shunts requiring implantation of a second and even third devices and was judged not to be as cost effective as surgery. The use of spring coils (single or multiple) for duct occlusion has reversed the cost effectiveness argument in favour of transcatheter occlusion. Occlusion of septal defects has been more difficult and a wide range of double disk devices has been developed. Their main drawback has been the requirement for adequate tissue margins around the defect to achieve occlusion without the device impinging on nearby valves. The surgeon under direct visualisation can stitch a patch in place with little or no margin. Despite these limitations over a thousand patients worldwide have had trial septal defects treated by transcatheter occlusion. Unfortunately one of the devices (the Lock clamshell device, which was a modification of the Rashkind double umbrella) had an 83% incidence of fractures of its arms, but without reported clinical consequences as the device was well integrated into the septum by that stage. Further device application for septal defects requires greater materials testing before widespread clinical use. Devices have also been used for occlusion of ventricular septal defects. This has been especially useful for multiple muscular defects which can be difficult for the surgeon to reach or prolong a complex cardiac reconstruction. Devices have also been used to occlude perimembranous defects but devices in this location may interfere with aortic valve function and require later surgical removal. Clearly surgery remains the treatment of choice for large perimembranous or malalignment ventricular septal defects.

An example of where interventional cardiology may complement surgery is in patients with single ventricle undergoing a right heart bypass operation (Fontan or total cavopulmonary connection) where surgical mortality and morbidity can be reduced by leaving a small hole (fenestration) in the channel bringing blood from the inferior vena cava directly to the pulmonary arteries which allows a proportion of blood to escape directly into the systemic circulation thus maintaining cardiac output and ensuring that the pressure in the veins does not rise too high. This is of course at the expense of some degree of cyanosis. At a later stage, if this fenestration has not closed spontaneously, it can be closed with a device if test occlusion shows that device occlusion would be well tolerated. However it remains to be shown whether the abolition of mild cyanosis and the potential risk of right to left thromboembolism is worth the reduction of exercise capacity and increased venous pressures that may result from fenestration closure.

Many patients undergo a staged Fontan procedure, with the first stage usually consisting of connection of the superior vena cava to the pulmonary arteries (bidirectional Glenn anastomosis) and a second stage where the inferior vena cava is channelled to the pulmonary arteries. The surgeon can prepare the way for the second stage to be accomplished in the cardiac catheterisation laboratory by leaving a large hole in a baffle that potentially connects the inferior vena cava to the pulmonary arteries and also leaving a tiny connection between the cardiac end of the superior vena cava and pulmonary arteries. The interventional cardiologist can then enlarge this connection with a short stent and close the hole in the baffle with a device. This staged procedure may avoid the prolonged hospitalisation due to pleural drainage seen in many of these patients. However this is a relatively novel procedure whose role in the management of univentricular heart remains to be established.

Coil occlusion of unwanted blood vessels such as aortopulmonary collateral arteries, coronary artery fistulas, arteriovenous malformations, and venous collaterals is increasingly effective because of improvements in catheter and coil design allowing catheters to deliver coils to very distant parts in a controlled fashion.

Interventional electrophysiology
Pacemaker implantation is required for congenital and postoperative complete heart block and for sick sinus syndrome, and is now usually performed in the cardiac catheterisation laboratory using the transvenous route rather than surgical epicardial placement. This is especially important for atrial pacing where epicardial leads generally perform poorly. We implant single chamber systems transvenously in infants between 2.5 and 8 kg and dual chamber systems, if indicated, in children over 8 kg. Concern remains over long term venous access if the pacing leads should have to be replaced.

The greatest advance in the last five years in the management of arrhythmias in infants and children has been the introduction of radiofrequency catheter ablation. Most arrhythmias can be cured with this technique. Most infant tachycardias are related to accessory pathways and resolve spontaneously in the first year of life. However some tachycardias are incessant and can be very difficult to control with drugs and may induce a cardiomyopathy. These tachycardias are relatively easy to treat with radiofrequency. Large tipped ablation catheters are available for infants and are used to map the offending accessory pathway or ectopic focus and then 500 kHz of radio waves is applied to heat the subjacent tissue to around 55°C. The scars created are discrete but in experimental studies may grow with the heart, but clearly if the tachycardia was life threatening the created scars are probably of little clinical concern. The technique is more often applied to older children and adolescents with forms of Wolff-Parkinson-White syndrome who don't wish to have a life time of drug treatment.

Another important development is the implantable cardioverter defibrillator, which has now been miniaturised enough to allow transvenous implantation in children with resuscitated sudden arrhythmic death, usually due to long Q-T syndrome or hypertrophic cardiomyopathy.

Balance between interventional cardiology and surgery
The growth of interventional cardiology has undoubtedly reduced the surgical workload in terms of numbers. How-
ever the amount of time spent by surgeons in operating theatres has probably not changed much. Although the simpler defects are dealt with in the cardiac catheterisation laboratory, more complex lesions such as hypoplastic left heart syndrome, which previously would not have been treated, are increasingly being operated on by cardiac surgeons. Furthermore, interventional cardiology can complement the management of these complex patients resulting in a better overall outcome for the child born with congenital heart disease. Interventional cardiac catheterisation has its own set of complications: vessel rupture, device embolisation, arterial or venous thrombosis, and radiation exposure. These complications can be reduced by careful patient and device selection, meticulous technique, low dose pulsed fluoroscopy and most importantly operator experience. We have probably so far only witnessed the beginning of interventional cardiology and await further developments in catheter and device design to improve and widen its application in the treatment of congenital heart defects.

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15 Palmar JC, Sibbitt RR, Reuter SR, Tso PO, Rice WJ. Expandable intralum
25 Hausdorf G, Schneid M, Kondorosi, AV pacemakers: reprogramming and compo


When science sneezes the journal catches a cold

This month we have published an anonymous contribution warning of a bleak future for UK paediatric clinical research. As editors we are already feeling the drought. Some senior academics refuse our request to review papers; one told us that his institution disparaged such work as unproductive for the department. Invitations to write commissioned articles are often declined or may even go unanswered. We do not know if this is because of pressure of work or whether it reflects a change in priorities.

Potentially more damaging is the reluctance of some members of the college whose journal we edit to submit papers. Rather than present their findings to the audience which should benefit most, they may be deflected by the need to amass more points for the research assessment exercise.

We remain optimistic, however. The Archives of Disease in Childhood is the highest rated European paediatric journal with an impact factor that is rising year on year. We continue to receive a large number of original scientific papers, such that we can afford to be selective in publishing only the best 30%.

Perhaps our anonymous contributor can take heart from the fact that a healthy journal reflects healthy science.

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Editors