Future directions in interventional cardiology

It is now more than 30 years since the first percutaneous coronary intervention. This period has seen interventional cardiology develop faster than any other area of cardiovascular medicine. There are now established catheter-based treatments for a range of coronary, valvular and congenital heart diseases. New interventional techniques and devices continue to expand treatment options and enhance outcomes for patients with cardiovascular disease. This article reviews some of these revolutionary therapies and predicts how their use will shape the future of interventional cardiology.

Coronary interventions

The modern day interventional cardiologist is now equipped to tackle extremely complex coronary artery disease which was previously only amenable to surgical revascularization. Despite recent technical advances, the old foes of chronic total occlusions and bifurcation lesions remain challenging. The procedural success rate for chronic total occlusion percutaneous coronary intervention has remained static (British Cardiovascular Intervention Society, 2008), despite enhanced guidewire technology and novel techniques, such as the retrograde approach and the sub-intimal tracking and re-entry technique (STAR). Ultimately a move towards super-specialized chronic total occlusion operators may prove to be the most important advance. Higher case volume and increased familiarity with the available technologies will lead to improved technical success rates and better outcomes for this subgroup of challenging coronary interventions.

Bifurcation lesions also have consistently lower rates of procedural success and higher rates of restenosis when compared with other coronary interventions (British Cardiovascular Intervention Society, 2008). A number of two-stent techniques to treat these lesions exist. Each technique has advantages and disadvantages, but generally any two-stent strategy is associated with longer procedural times, higher contrast use and more post-procedural myocardial infarctions than the provisional approach of implanting one stent within the main vessel (Hildick-Smith et al, 2010).

At present the provisional approach is the default strategy for most bifurcation lesions (Legrand et al, 2007) but it is not without its own limitations; notably the inability to guarantee side branch access, difficulty in rewiring the side branch because stent struts are obstructing the vessel ostium, and an inability to fully cover the side branch ostium.

As a result, dedicated bifurcation stents have been designed to specifically address some of these shortcomings (e.g. Multi-link Frontier Abbott Vascular Devices, Redwood City, California, USA; Guidant Corporation, Santa Clara, California, USA; Tryton SB stent, Tryton Medical, Massachusetts, USA) (Lefevre et al, 2005; Onuma et al, 2008). The majority of the devices are aimed at facilitating the provisional approach, allowing constant access to the side branch as well as ensuring full coverage of the side branch ostium. The use of each device will have a learning curve and randomized trials to test their true efficacy and safety are needed to define their place in routine clinical practice.

Non-coronary interventions

Transcatheter aortic valve interventions

Until recently catheter-based therapies for aortic stenosis consisted only of balloon valvuloplasty. This is an effective short-term treatment for aortic stenosis but the incidence of restenosis is too high for it to be considered a definitive treatment. As a result, transcatheter technologies to deliver a bioprosthetic valve, displacing the native valve, have been developed and recently substantial progress has been made in this area.

The Edwards' Sapien valve (www.edwards.com/products/transcatheter-valves/sapienthv.htm) and Corevalve's Revalving system (www.medtronic.com/corevalve/other.html) are the currently available devices (Grube et al, 2007; Webb et al, 2007). These valves are designed to be delivered via a retrograde approach from the femoral artery around the aortic arch and into position.

The Edwards' Sapien valve is balloon mounted, and deployed with a single balloon inflation during rapid right ventricular pacing to reduce cardiac output whereas the Corevalve Revalving system involves a self-expanding nitinol stent platform. These valves are delivered via 18 or 19 French femoral sheath (approximately 6 mm diameter). Some eligible patients with aortic stenosis do not have sufficient calibre ilio-femoral vessels to accommodate this system and a minimally invasive surgical technique, involving a mini thoracotomy to deliver the Edwards' Sapien valve through the apex of the beating heart, has therefore been developed, the so-called 'trans-apical approach'.

At present the use of transcatheter aortic valve intervention is restricted to elderly patients with significant comorbidities which preclude conventional aortic valve surgery. By the end of June 2009 around 8000 transcatheter aortic valve interventions had been performed in Europe. Data in this high-risk group suggest the 30-day mortality is around 9%, with 1-year survival around 76% (Thomas et al, 2010). These early results are extremely promising. Future advances in transcatheter valve technology will lead to the development of smaller delivery systems, improved procedural success rates and a reduction in procedural cost (currently approximately €15 000/procedure).

Transcatheter aortic valve intervention therapy is likely to have an expanding role in the management of aortic valve disease. It is quite conceivable that this therapy will become first line for all elderly patients, irrespective of co-morbidity, and for all patients who have previously had coronary artery bypass graft surgery. Ultimately transcatheter aortic valve intervention may be the preferred strategy for all patients with aortic valve disease who do not require concomitant coronary artery bypass graft.

Percutaneous mitral valve interventions

The mitral valve is more challenging to treat percutaneously. Mitral valve anatomy is far more complex than that of the aortic valve. As a result, transcatheter therapies for mitral regurgitation are not yet as evolved as those which treat aortic stenosis.

The most mature technology is the Evalve MitraClip. This is delivered anterogradely via a transeptal approach. The clip is implanted on the mid portion of each mitral leaflet under transoesophageal echocardiography guidance. It can be used to treat mitral regurgitation as a result of leaflet prolapse, flail leaflets or functional regurgitation caused by annular dilatation. The initial results are promising, demonstrating the ability to safely and effectively deliver the clip with reduction in the severity of mitral regurgitation and good 1-year outcomes (Feldman et al, 2009). The procedure is technically demanding, but with experience procedure times are falling and results are improving.

Alternative approaches to percutaneous mitral valve repair are being investigated. Several companies are developing percutaneous mitral annuloplasty devices. This technology exploits the anatomical relationship of the coronary sinus to the mitral valve annulus. The annuloplasty device is delivered into the coronary sinus via the venous system. The device crimps the coronary sinus and shrinks the mitral valve annulus and is primarily of use in the treatment of functional regurgitation.

Early results of percutaneous mitral valve interventions are encouraging. Further evolution of this therapy is needed, along with trial data to support the efficacy and safety, before we see the explosion in use that has been seen with transcatheter aortic valve intervention.

Non-cardiac interventions

Renal nerve ablation

Hypertension is a major global public health concern which can be a challenge to treat with the medical therapies currently available. Recently a novel technique has been developed which disrupts renal sympathetic nerves percutaneously via the lumen of the main renal artery with a catheter connected to a radiofrequency generator. The nerves, which lie within and immediately adjacent to the wall of the renal artery, are central to the development and maintenance of hypertension. Initial studies have shown catheter-based renal denervation causes substantial and sustained blood-pressure reduction, without serious adverse events, in the vast majority of patients with resistant hypertension who were treated (Krum et al, 2009).

Prospective randomized control trial data are required to definitively determine the role of renal denervation therapy in patients with refractory hypertension. However, if the procedure is found to be safe and effective in randomized control trials then it may become a mainstream therapy for patients refractory to or intolerant of medical therapy. Perhaps one day this procedure will be considered a first-line curative therapy, as an alternative to multiple lifelong medications for hypertension.

Conclusions

Interventional cardiology has an exciting future. Emerging technologies are redefining the treatment options for many cardiovascular diseases. With continued development, and increasing availability they will become established first-line therapies and have a profound impact upon the lives of our patients. BJHM

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KEY POINTS

- Modern interventional cardiologists can effectively treat complex coronary artery disease that previously would have only been amenable to surgical therapy. In the future evolving techniques and technologies will further advance the boundaries of coronary intervention.
- Catheter-based therapies for valvular heart disease are now available and evolving rapidly. Eventually it is likely they will become first-line therapy for many patients.
- Renal nerve ablation is a promising therapy for refractory hypertension and may one day be considered a curative therapy.

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