

Cardiac interventions have been a spectacular journey marked by undeterred outcome of genuinity, serendipity and proper channelization of scientific knowledge and skills. Cardiac catheterization began in 1711 with equine biventricular catheterization by Hales. However, the dramatic beginning was with Forsmann's 1929 right heart self catheterization; Cournand, Richards and others unlocked the right heart in 1940's; Zimmerman and others unlocked left heart in 1950's and Coronaries were unlocked by Sones in 1958. Dotter's accidental catheter recanalization of peripheral artery in 1963, followed by Gruentzig's balloon angioplasty in mid 1970's led to today's panoply of devices used percutaneously for revascularization.

Over the past decade, the focus of catheterization has changed dramatically from its primary diagnostic function to a conduit of therapies. Today, therapeutic catheterization techniques have replaced conventional surgery for many lesions. The percutaneous transcatheter procedures are broadly grouped as Dilatational (Septostomy, Valvuloplasty, Angioplasty and Endovascular Stenting) or as Occlusions (Vascular embolization and Device closure of defects).

Cardiac Interventions can be used in dealing with diseases such as:

1. Coronary Artery Disease
2. Heart Valve Diseases
3. Congenital Heart Disease
4. Hypertrophic Cardiomyopathy
5. Heart Failure
6. Cardiac Arrhythmias

### **CORONARY ARTERY DISEASE**

The treatment of Coronary artery disease has multiple facets. It is recognised increasingly that lifestyle changes -- a healthier diet, exercise, smoking cessation and advanced medical therapies including statins, beta blockers and antiplatelet therapy -- are the cornerstones of such treatment. Percutaneous Coronary Intervention has become the preferred approach and has evolved substantially from early days of Plain Open Balloon Angioplasty (POBA) to Bare Metal Stent (BMS), Drug Eluting Stent (DES) and Bioabsorbable Vascular Scaffold (BVS), rotational atherectomy and other interventions for patients with acute coronary syndrome, limiting angina or significant ischemia with appropriate anatomy. The usage of advanced imaging techniques like fractional flow reserve (FFR), intravascular ultrasound (IVUS), optical

coherence testing (OCT) and infrared spectroscopy has not only enabled the clinician to facilitate more accurate navigation inside vessel but in proper and adequate stent deployment as well.

Cardiac assist in the catheterization lab had its origins in the form of extracorporeal membrane oxygenators (ECMO), which were used to support children in respiratory failure. With the clinical introduction of an Intra-aortic balloon pump (IABP) by Kantrowitz in 1968, cardiologists diagnosing and treating patients with acute coronary syndromes began applying IABP therapy in the catheterization lab but usually in concert with the surgeons. Cardiopulmonary support (CPS) systems were introduced in the 1970s, filling a void between what the IABP could provide in the catheterization lab and what full cardiopulmonary bypass provided in the surgical suite. Therefore, although the IABP gained widespread use in the catheterization lab based on its relative ease of insertion, its lack of hemodynamic impact leading to a reliance on inotropic drug support limited its ability to meet the ideals described previously. Development of cardiac assist in the catheterization lab has, therefore, progressed through a number of iterations during the last 50 years. With each generation, the technology has struggled with the challenges of becoming either easy to implant, safer for the patient, and/or more effective in providing circulatory support and myocardial protection. The Impella technology is the latest generation of cardiac assist and represents a significant step in the history of technology development described previously. Its design facilitates a support strategy that represents the ideal of cardiac assist—safe and simple use consistent with both elective and emergent clinical environments, while supporting systemic hemodynamics and protecting the myocardium from ischemic damage.

### **HEART VALVE DISEASES**

Typical valvular stenosis is characterised by fusion, partially absent or commissured valves with small eccentric orifice that is visualised angiographically. The dilating balloon catheter is positioned over a wire across the valve and balloon is inflated many times till waist of the stenotic lesion disappears.

Before 1984, when Inoue et al first described the clinical application of percutaneous mitral balloon valvuloplasty (PMBV),— surgical mitral commissurotomy was the preferred option for patients who had severe mitral stenosis (MS). Since its introduction, percutaneous mitral commissurotomy has demonstrated good immediate and midterm results and has replaced surgical mitral

Multiple percutaneous approaches for the treatment of mitral regurgitation (MR) are under development and various percutaneous approaches aimed primarily at the treatment of functional or ischemic dysfunction include: (1) Direct annular plication simulating surgical suture annuloplasty, (2) Thermal remodeling of mitral annular collagen, (3) Left ventricular remodeling using a percutaneously placed transventricular device, (4) A transatrial system with anchors in the coronary sinus and interatrial septum, and (5) a novel percutaneous ring for the treatment of functional TR.

Transcatheter aortic valve implantation (TAVI) was first applied in an early animal study by Danish cardiologist Anderson in his garage in 1992 and approximately 8,000 patients have now been treated with this technology worldwide. The procedures have been predominantly performed using two different devices with almost equal frequency: the Edwards Lifesciences (Irvine, CA) Sapien systems and the Medtronic, Inc. (Minneapolis, MN) CoreValve system. Although both systems have been shown to be safe and clinically effective, albeit with a limited duration of follow-up thus far, the principal difference in design is that the Edwards systems have employed a balloon-expandable concept, whereas the CoreValve device is self expanding.

### CONGENITAL HEART DISEASE

Transcatheter occlusion of intracardiac and extracardiac communications has been revolutionised by the development of Amplatzer devices. These are made from a cylindrical Nitinol wire mesh formed by heat treatment into different shapes. A sleeve with a female thread on the proximal end of the device allows attachment of a delivery cable with a male screw. The attached device can be pulled and pushed into the loader and delivery sheaths respectively. A family of devices has been produced to occlude ostium secundum atrial septal defect (ASD), patent foramen ovale (PFO), patent ductus arteriosus (PDA) and ventricular septal defect (VSD).

While the four lesions described above constitute the bulk of adult structural heart disease practice, there are countless lesions that require treatment in this patient population on a less frequent basis. They include stent placement for coarctation of the aorta, stenting of stenotic pulmonary arteries, pulmonary or systemic veins, surgically created baffles used to treat transposition of the great arteries, or conduits from the ventricles to the great arteries to bypass inoperable subvalvular obstruction, pulmonary arteriovenous malformations. Coronary fistula closure is a regularly performed procedure. Pulmonary and aortic balloon valvuloplasty are not infrequently performed procedures for stenotic valves. With experience in device use and sophisticated techniques, closure of perivalvular leaks around mechanical valves, aortoatrial fistulas, aortic pseudoaneurysms, and ventricular septal defects of both congenital and post myocardial infarction etiology is possible.

### HYPERTROPHIC CARDIOMYOPATHY

Hypertrophic cardiomyopathy (HCM) is a genetic cardiovascular disease. It is defined by an increase in left ventricular wall thickness that is not solely explained by abnormal loading conditions. This disorder is caused by a mutation in cardiac sarcomere protein genes and is most frequently transmitted as an autosomal dominant trait. HCM has a variable presentation.

Although not required for the diagnosis of hypertrophic cardiomyopathy, a diagnostic cardiac catheterization is useful to determine the degree of outflow obstruction, cardiac hemodynamics, the diastolic characteristics of the left ventricle and LV anatomy, and, of particular importance, the coronary anatomy. Cardiac catheterization is also reserved for situations when invasive modalities of therapy, such as a pacemaker or surgery, are being considered.

Therapeutic cardiac catheterization interventions, utilized in well selected cases of hypertrophic cardiomyopathy, include transcatheter septal alcohol ablation to relieve the LV outflow obstruction by intentional infarction of a portion of the interventricular septum.

### HEART FAILURE

Heart failure is now the great epidemic, and remains primarily due to hypertension, valve or coronary disease. Indeed, while we've been "up to our necks" in coronary intervention for some time now, we are certainly now at least "knee deep" in valvular disease and at least "dipping our toes" into hypertension. Medications will remain a mainstay of heart failure management, and rightly so, but they should ideally be complementary to other forms of treatment that further unload the heart or reverse the primary disorder. The time has come for interventional cardiology to take its rightful place in the comprehensive and multi-disciplinary management of patients with heart failure

Interventional therapies may be able to improve cardiac function and reverse heart failure. Examples abound, and include (1) percutaneous cardiac assist device therapy to facilitate multi-vessel high-risk intervention and complete revascularization or as a bridge to recovery with reduced infarct size in acute myocardial infarction, with or without cardiogenic shock; (2) percutaneous aortic and mitral valve repair and/or replacement to reverse or halt negative remodeling and improve cardiac output; (3) stem cell and gene therapy delivery to improve ventricular function; (4) cardiac resynchronization (CRT) to improve stroke volume; (5) atrial septal defect closure, paravalvular leak repair, and other advanced congenital defect treatment such as coarctation repair; and (6) alcohol septal ablation for hypertrophic cardiomyopathy to reduce outflow tract obstruction and improve both mitral regurgitation and diastolic function.

Together, perhaps we will not only prevent some forms of heart failure from developing, such as that which occurs after a large myocardial infarction, but produce robust and sustained cardiac function recovery in those who already suffer from the disease, such as those with chronic ischemia and ventricular dysfunction or ongoing

hemodynamic stress from valve dysfunction.

## CARDIAC ARRHYTHMIAS

Cardiac arrhythmias can present as benign ectopics or as life-threatening arrhythmias and sudden cardiac death. Clinical cardiac electrophysiology is the study of the electrophysiology of the heart and all aspects of management of cardiac arrhythmias. The invasive electrophysiological study was initially purely diagnostic, but recent advances in technology has allowed us to intervene and hence the term interventional electrophysiology. The interventional therapies include permanent pacing for bradyarrhythmias, arrhythmia surgery for arrhythmias, percutaneous catheter ablation and implantable devices for tachyarrhythmias.

The treatment of bradyarrhythmias with permanent pacemaker implantation represents the first interventional therapy for patients with cardiac arrhythmias. Previously, patients with tachyarrhythmias could only be cured by open heart surgery utilising intraoperative map guided surgery and ablation of the arrhythmia. Catheter ablation has completely revolutionised the treatment of these patients.

RF ablation has become the technique of choice to cure patients with recurrent paroxysmal SVT due to AV re-entrant tachycardia using an accessory pathway, AV nodal re-entrant tachycardia, atrial tachycardia and atrial flutter. It is also used for AV nodal ablation followed by pacemaker insertion or AV nodal modification in patients with poorly controlled atrial fibrillation. Patients with idiopathic non-ischaemic VT arising from the left ventricle or right ventricular outflow tract can similarly be cured. For all these patients, RF ablation offers curative therapy, thus eliminating recurrent symptoms, life-threatening attacks, tachycardia cardiomyopathy and need for life-long drug therapy.

For patients with resuscitated sudden cardiac death or at high risk for sudden death, the implantable cardioverter defibrillator (ICD) is the only technique that has significantly improved survival from sudden cardiac death.. Thus the ICD can prevent sudden death, but the main limitation is the cost of the device and it is not suitable in patients who have severe heart failure.

In conclusion, interventional electrophysiology represents a tremendous leap forward in the management of cardiac arrhythmias. With catheter ablation, it offers a safe curative therapy for patients with recurrent SVTs and VTs and with the ICD, prevents sudden cardiac death in patients who have been resuscitated from it or who are at risk for it.

## CONCLUSION

“Innovation in medical technology is key to the advancement of medicine. The practice of interventional cardiology will undoubtedly be different in the next decade. Coronary intervention will remain the dominant procedure for the interventionalist, and the number of procedures will grow slowly as the population ages. The increase in peripheral interventions probably will be greater than for coronary, but the greatest and most profound change will be in the growth of valvular heart

disease interventions. New technology and improved imaging will be necessary and likely. The interventional laboratory of the future will be a different one from today, and the interventionist of the future will need to be skilled in many more techniques than just coronary interventions.

However, during all this process of innovation, interventional cardiologists are exposed to radiation and need to wear heavy lead aprons. Studies show 60 percent of interventional cardiologists has spine issues and 51 percent have the beginnings of cataracts along with a significant increase in incidence of brain tumours. New technology is available to address radiation and taking the cath lab staff and the operator out of the radiation field by using robotic systems along with new radiation protection systems like RdPad and Trinity protection systems to help block radiation scatter. The Zero Gravity ceiling gantry mounted lead suit system that takes the weight of lead aprons off of physicians are also available.

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