Ancillary techniques in interventional cardiology

John M. Lasala, George Chrysant, Adrian Messerli

Introduction

The Ancillary Techniques in Interventional Cardiology Section will be diverse in covering a number of cutting balloon devices such as directional coronary atherectomy, rotational atherectomy, and distal embolic protection. Limitations on space prevent an elaborate discussion on other techniques that would qualify for the chapter. These three were chosen because they span over a decade and a half of interventional cardiology. Some are more historical in nature; all have had a substantial impact at one time during the development of interventional cardiology techniques.

The rotational atherectomy system was developed by Dr. David C. Auth, PhD, two decades ago. It consists of a nickel-plated brass elliptical burr coated on the leading edge with 20–30 micron diamond chips. The chips protrude from the nickel plating forming a cutting surface of approximately 5 microns, therefore ablating atherosclerotic plaque to the size of a red blood cell. The ablated material can then pass through the microcirculation and is consumed by the reticular endothelial system. The burr is attached to a long flexible drive shaft with a central core clearance of 0.009 inch stainless steel guidewire. The drive shaft is driven by compressed nitrogen and housed in a Teflon sheath that can be irrigated with a flush solution containing a cocktail of heparin, nitroglycerin, or calcium channel blockers at the discretion of the operator. A fiber optic light probe helps rotate the shaft at 140–180,000 rpm. A higher speed may be necessary when encountering heavily calcified lesions. Reduction of friction of the drive shaft with the Teflon-coated sheath has recently been improved by the addition of Rotaglide™ solution consisting of a phospholipid emulsion constituting nature’s “10W40”. It minimizes heat and improves the efficiency of the drive shaft. Rotational atherectomy is a very operator dependent technique. Though comprising less than 10% of all procedures in the United States, it enables the operator to perform cases that involve heavy degrees of calcification to be performed where other technologies fail. The rotablator is capable of cutting into elastic plaque whether or not it is calcified, by applying the principle of differential cutting. The normal artery being more elastic in nature, will deflect from the burr itself, similar to shaving one’s face in the morning – the beard reflected off the skin is preferentially cut. Rotational atherectomy is successful only with diligent attention to technique and detail.

The field has been advanced by a number of high volume practitioners who have previously published on optimal techniques, such as Maurice Buchbinder at La Jolla, California; Mark Reisman at Swedish Hospital, Seattle, Washington; Samin Sharma, Mount Sinai Medical Center in New York City; Gregory Braden, Winston Salem, North Carolina; and Ted Feldman at Abbott Northwestern Hospital, Chicago, Illinois.

Directional coronary atherectomy (DCA) was intended to improve the safety and efficacy of revascularization compared to balloon angioplasty by controlling plaque removal. The device was conceived and initially tested by Dr. John B. Simpson, MD at Sequoia Hospital in Redwood City, California. The debulking strategy was developed in response to the major problems of balloon angioplasty during the early 1980s and was designed to decrease the primary failure and abrupt closure rates while minimizing restenosis.

The entire concept of atherectomy was introduced by Dr. Simpson who developed the prototype known as the Simpson Coronary AtheroCath. This consists of a metal housing with a fixed balloon, a nose cone collection chamber and a hollow tube which accompanies a 0.014 inch...
guidewire. A cup-shaped cutter inside the housing is attached to a flexible drive shaft and is activated by a hand-held battery operated motor driver unit. The AtheroCath is advanced into the lesion with the cutting chamber directed into the plaque bulk. The blade is then withdrawn exposing the plaque to the chamber and cutting surface. When the balloon is inflated it will further push the cutting window into the plaque. The cutter is manually advanced while rotating the cutter at approximately 2000 rpm. The excised atheroma is then pushed forward and stored in the distal nose cone, allowing for collection.

The development of directional coronary atherectomy and its practitioners, particularly Drs Donald Baim and Richard Kuntz of Harvard, devised effective debulking strategies in an optimal manner, proposing the “bigger is better hypothesis”. This hypothesis stated that although there is an obligatory late loss of lumen diameter that occurs after coronary intervention, a larger lumen would have a higher probability of avoiding restenosis and producing fewer symptoms. Directional atherectomy with its controlled debulking was developed as a means of capitalizing on this hypothesis. Other operators, notably Chuck Simonton working at Charlotte, North Carolina, have demonstrated that ultrasound guidance of debulking can further perfect outcomes. In fact, directional coronary atherectomy, in common with stenting, is the only device tested in a prospective randomized manner, to demonstrate a reduction in angiographic rates of restenosis. Recovery of atheroma, unlike its destructive counter part, rotational atherectomy, also was helpful to vascular biologists, providing a biopsy specimen that could be evaluated for procoagulate activity, neointimal formation, and differences in the plaque composition in patients with stable and unstable angina. Today, the device has largely been superseded by intracoronary stenting which is considerably simpler and less operator dependent. It has found use in bulky areas such as bifurcation lesions in the coronary tree while an updated version of directional coronary atherectomy (Fox Hollow) has been employed in peripheral arteries to debulk large lesions in the lower extremity.

Embolic protection devices round out the trio of ancillary technologies. This is the most recently developed and currently, the most commonly used in contemporary intervention. This is a rapidly burgeoning field with many major medical device companies currently pursuing FDA approval with an embolic protection device. The landmark papers regarding the SAFER Trial established embolic protection as the method of choice in reducing MB/CPK release related to saphenous vein graft intervention. Application into both the coronary tree, carotids and renal intervention will be helpful to protect against end-organ damage. The number of articles being reviewed and published in this field will fill a rather large book chapter over the next three years.

The development of these techniques stand as testament to the ingenuity of the engineers, private industries and interventional cardiologists who have helped make these devices a reality. Necessity truly being the mother of invention has been the guiding force to the design and construction of ancillary techniques involved in interventional cardiology. All have given us important additions to our armamentarium in caring for our patients with coronary disease.