required with conventional stents, which is expensive and does not eliminate all late-occurring thrombosis, could be avioded with bioabsorbable stents.

Features of five of the bioabsorbable stents in development are listed in Table 1.

Table 1. Bioabsorbable Stents in Development

Stent	Features	Advantages	Drawbacks
Igaki-Tamai bioabsorbable stent	PLLA zig-zag helical coil with straight bridges	During absorption, hydrolysis of lactide units produces lactic acid that is metabolized to carbon dioxide and water; radiolucent with radio-opaque markers	Strut 170 microns, thicker than contemporary metallic stents; cumbersome to use
Bio-absorbable magnesium stent (Biotronik)	Laser cut from tubular magnesium WE-43, sinusoidal in-phase hoops linked by straight bridges	Balloon-expandable; radial strength at implantation similar to stainless steel stents; no stent thrombosis; completely absorbed	Strut 165 microns; radiolucent, no radio-opaque markers; placement challenging; radial support lost early; no antiproliferative drug release; high rate of restenosis
BVS Everolimus-eluting bioabsorbable PLLA stent (Abbott Vascular)	PLLA backbone contains and controls release of antiproliferative drug everolimus; different polymerization than Igaki-Tamai	Release rate of everolimus (80% by 30 days) similar to that of Xience V metallic stent and similar low internal obstruction; strut thickness and crossing profile (1.4 mm) similar to those of Cypher stent	Radial strength at body temperature lower than many metallic stents
Bioresorbable coronary stent (REVA Medical)	Absorbable tyrosine-derived polycarbonate polymer metabolizes to amino acids, ethanol, carbon dioxide	Modifiable absorption time; balloon-expandable without distortion; iodine for radio-opacity	200 micron struts are thick with 1.7 mm crossing profile; side effects include Q-wave myocardial infarctions, target lesion revascularization
Bioabsorbable Therapeutics stent	Repeating salicylate molecules linked by adipic acid molecules; elutes sirolimus and also releases salicylic acid	Salicylic acid expected to counteract inflammation	200 micron struts. 2.0 mm crossing profile caused intimal hyperplasia leading to re-design

BVS=bioresorbable vascular scaffold; PLLA=poly-L-lactic acid.

To summarize, the ideal bioabsorbable stent should be easy to handle and implant, and be detectable by imaging to ensure accurate post-dilatation and placement of additional stents without gaps or overlaps. Having a detectable absorbable stent also means that complete resorption can be confirmed. In addition, at implantation, bioabsorbable stents should have an initial strength similar to that of conventional metal stents and be able to maintain this strength for sufficient time to help overcome the early negative remodeling forces that occur soon after PCI, this negative remodeling is the main cause of restenosis after balloon angioplasty. Stenting via PCI also causes an intimal hyperplastic or excessive healing response, hence the need for a stent that is capable of releasing antiproliferative drugs. Ideally, repair with a bioabsorbable stent would achieve and maintain vessel movement, increase blood vessel lumen size, and produce a reduction in plaque area. In addition, it would be desirable to regain appropriate physiologic responses to exercise and the ability to dilate in response to local ischemia in healed arteries.

The ideal bioabsorbable stent should also result in a healed, normally functioning vessel with no foreign body (stent) remaining, and no restenosis or late thrombosis development. Early encouraging results, particularly the results from the bioresorbable vascular scaffold everolimus-eluting bioabsorbable poly-L-lactic acid stent, although they require confirmation in larger clinical trials in patients with complex lesions, suggest the ideal bioabsorbable stent can be developed.

Therapeutic Strategies for Hemodynamic and Circulatory Support After PCI

Written by **Mary Mosely**

Treatment strategies for ST-segment elevation myocardial infarction (STEMI) utilize both pharmacological therapies and devices designed to restore coronary blood flow. While these therapies are generally effective, a proportion of patients with STEMI will develop cardiogenic shock, one of the leading causes of inhospital death post MI. Despite an optimal pharmacomechanical approach, revascularization, and hemodynamic support, the mortality in patients with STEMI complicated by cardiogenic shock remains high, said Hany Eteiba, MD, University of Glasgow, Glasgow, Scotland.

Prof. Eteiba reviewed effective and active circulatory support strategies that can be used in patients with cardiogenic shock. Extracorporeal membrane oxygenation (ECMO) and left ventricular assist device (LVAD) are two of these approaches and Prof. Eteiba discussed how these devices can be utilized in clinical practice.

Hemodynamic support for patients with acute myocardial infarction complicated by shock can be provided through a variety of available devices (intraaortic ballon pump, Impella, Tandem Heart, etc) that work to increase cardiac output.

Circulatory support can also be provided by ECMO or a LVAD. ECMO is performed by obtaining venous and arterial access and does not require a sternotomy. ECMO can serve as a bridge to recovery, bridge to another

CardioAlex2013_Full Edition.indd 32 10/20/2014 3:10:06 PM

hemodynamic support device (total artificial heart or LVAD), or transplantation. The evidence supporting the use of ECMO and the survival rates are shown in Table 1.

Table 1. Summary of Evidence for Extracorporeal Membrane Oxygenation and Survival Rates after Cardiogenic Shock

Study	Patients	Survival Rate	Cardiogenic Shock Etiology
Golding et al. (1992)	91	25.3%	Post-CABG
Muehrcke et al. (1996)	23	30.4%	Post-CABG
Magovern et al. (1999)	27	85%	UA or CHF
Formica et al. (2008)	18	27.8%	AMI/Post-CABG
Combes et al. (2008)	16	31.3%	AMI
ELSO (2009)	153	39%	Not defined

AMI=acute myocardial infarction; CABG=coronary artery bypass graft; CHF=congestive heart failure; US=unstable angina.

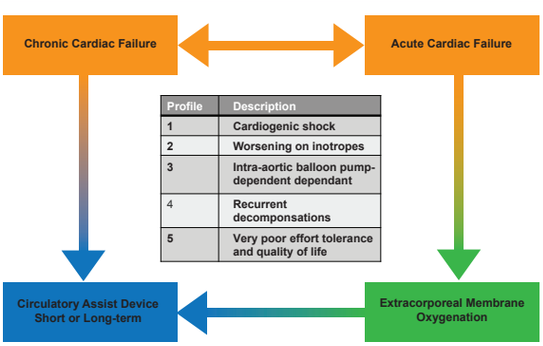
Golding LA et al. *Ann Thorac Surg* 1992; Muehrcke DD et al. *Ann Thorac Surg* 1996; Magovern GJ et al. *Ann Thorac Surg* 1999; Formica F et al. *ASAIO J* 2008; Combes A et al. *Crit Care Med* 2008; Thiagarajan RR et al. *Ann Thorac Surg* 2009.

The TandemHeart Pump is another circulatory support device utilized in the treatment of patients with cardiogenic shock. In two randomized, controlled trials, TandemHeart, when compared with IABP, improved some hemodynamics measurements. Treatment with TandemHeart did not reduce mortality and complications were increased.

The HeartMate II Long-Term LVAD is implanted surgically and is used as either a destination device or as a bridge to either recovery or transplantation. The HeartMate II is a rotary continuous-flow device that works in parallel with the native left ventricle. It has a percutaneous driveline, a fixed-speed operating mode, and is powered electrically. Some patients treated with a HeartMate II are able to be discharged home after implantation.

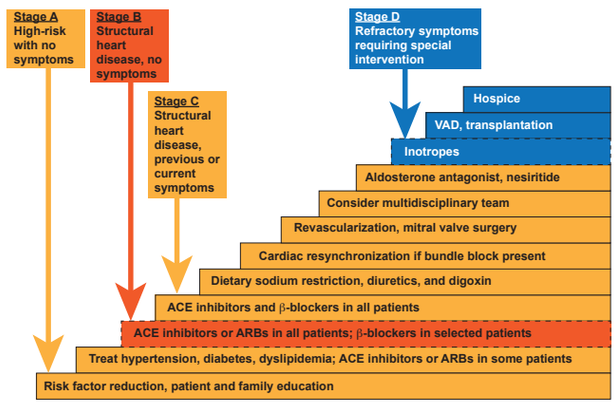
A treatment algorithm for the management of patients with cardiac failure after an MI is shown in Figure 1. Prof. Eteiba reviewed the evolution of cardiac failure in this patient population and treatment recommendations as the disease progresses (Figure 2).

Figure 1. Management of Patients With Cardiac Failure Post Myocardial Infarction



Reproduced with permission from H Etieba, MD.

Figure 2. Treatment Schema for Progressive Cardiac Failure Post-Myocardial Infarction



Reproduced with permissionfrom H Etieba, MD.

The incidence of cardiogenic shock for patients with with STEMI continues to decrease as revascularization rates increase and medical therapy has improved. For example, the TRITON TIMI-38 study [Wiviott SD et al. *Lancet* 2008] compared the oral antiplatelet prasugrel with clopidogrel. The overall trial showed a reduction in cardiovascular death, MI, and stroke with prasugrel. In addition, treatment with prasugrel reduced stent thrombosis, both early (through Day 30, 0.42% of patients with prasugrel compared with 1.44% of patients with clopidogrel, 71% relative risk reduction [RRR]), and late (Day 31 to Day 450, 0.42% compared with 0.91% of patients, 54% RRR).

The incidence of cardiogenic shock is greater among patients with multivessel coronary artery disease; yet, the optimal revascularization strategy for patients with STEMI and multivessel coronary artery disease remains undefined. The 2005 Practice Guideline from the American College of Cardiology, American Heart Association, and Society for Cardiovascular Angiography and Interventions, state that PCI should not be performed in a noninfarct artery during primary PCI in patients *without* hemodynamic compromise. The current guidelines do note that PCI of a noninfarct-related artery could be considered for patients if the lesion "appeared to be flow limiting in patients with hemodynamic instability". The 2012 Practice Guidelines from the European Society of Cardiology state that performing PCI in nonculprit vessels is discouraged because of a "gap of evidence." Numerous observational studies have been published which have found differing results; however, randomized trials are required for this question to be answered in a definitive manner.

CardioAlex2013_Full Edition.indd 33 10/20/2014 3:10:06 PM