Highlights of the 2003 Transcatheter Cardiovascular Therapeutics Annual Meeting: Clinical Implications

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In its fifteenth year, the Transcatheter Cardiovascular Therapeutics (TCT) Annual Meeting is one of the largest gatherings in interventional cardiology. This year’s session provided live case demonstrations of novel techniques and therapies, results of several clinical studies, and an excellent review of topics of interest for practicing interventional cardiologists. The meeting also afforded a venue for extensive industry exhibits, and the role of various devices utilized in interventions was prominent. We report the results of key clinical trials presented at the TCT meeting and discuss their clinical implications in addition to summarizing the new techniques/topics presented.

DRUG-ELUTING STENTS AND RESTENOSIS THERAPY

Given the success of the sirolimus-eluting stent in preventing restenosis (1), considerable efforts are being directed toward developing other drug-eluting stents (DES). Results from various studies with newer DES were presented at the TCT meeting.

TAXUS-IV. The Pivotal, Prospective, Randomized Trial of the Slow-rate Release Polymer-based Paclitaxel-eluting TAXUS Stent. Greg Stone, MD; Stephen G. Ellis, MD.

The TAXUS-IV study evaluated the effect upon restenosis of a stent that eluted the antiproliferative drug paclitaxel. The investigators enrolled 1,326 patients undergoing elective stenting, with single de novo lesions, 10 to 28 mm in length, treatable with one stent in vessels 2.5 to 3.75 mm in diameter. Patients were randomized to either a 1 mg/mm² slow-release paclitaxel-eluting Express (Taxus) stent or a bare-metal Express stent (Boston Scientific, Natick, Massachusetts) and received clopidogrel for six months. Exclusion criteria included prior percutaneous coronary intervention (PCI), planned atherectomy, myocardial infarction (MI) within 72 h, excessive vessel tortuosity or calcification, total occlusion, visible thrombus, bifurcation lesion, or initial Thrombolysis In Myocardial Infarction (TIMI) 0/1 flow grade. The primary end point was the nine-month rate of ischemia-driven target vessel revascularization (TVR).

The two groups were similar in baseline clinical characteristics, angiographic characteristics, the target vessel revascularized, and acute angiographic results. Nine-month TVR and target lesion revascularization (TLR) rates were 4.7% and 3.0% with the Taxus stent and 12.0% and 11.3% with the bare metal stent (relative risk [RR] = 0.39 and RR = 0.27, both p < 0.0001), respectively. No difference existed between the two groups in cardiac death, MI, or stent thrombosis at nine months. Significant RR reductions of 70% to 80% in TLR were seen in most patient and lesion subgroups, including diabetics, smaller vessels, and longer lesions.

A total of 732 patients were prospectively enrolled to have nine-month angiographic follow-up in TAXUS-IV, and 559 (76.4%) patients underwent angiography. The mean diameter stenosis in the analysis segment (5 mm proximal and distal to stent edge) was 39.8% with the bare-metal stent and 26.3% with the Taxus stent (p < 0.0001). Binary restenosis and in-stent late loss were 26.6% and 0.92 mm with the bare-metal stent and 7.9% and 0.39 mm with the Taxus stent (both p < 0.0001), respectively. Significant risk reductions for angiographic restenosis were seen in diabetics, in all lesion lengths, and in all vessel diameters with the Taxus stent except for larger reference vessel diameters (>3.0 mm) where the trend toward lower restenosis was not statistically significant (6.8% Taxus vs. 15.2% bare-metal stent, p = 0.10).


Preliminary safety and efficacy data for the antiproliferative compound everolimus (Novartis, Basel, Switzerland)-eluting Champion stents (Guidant, Temecula, California) were presented. A total of 106 patients were randomized to an everolimus-eluting stent (48 patients) versus its bare-metal counterpart (58 patients) in single de novo lesions of <18 mm length. In FUTURE-I, which enrolled 42 non-diabetic patients with simple lesions at a single center, late loss was 0.11 mm with the everolimus stent and 0.85 mm with the bare-metal stent (p < 0.0001) at six months. In FUTURE-II, diabetics (26.6%) and patients with more complex lesions were enrolled, and six-month late loss was 0.12 mm with the everolimus stent and 0.85 mm with the bare-metal stent (p < 0.0001). Binary restenosis was absent in the everolimus stent but noted in 19.4% of the bare-metal stents (p = NS).

ENDAVER-I. A Prospective Multicenter Pilot Trial of the Phosphorylcholine-based ABT-578-eluting Stent. Ian T. Meredith, MBBS, PhD.
This phase I safety study enrolled 100 patients with single de novo lesions of <15 mm, which were treated with a phosphorylcholine-based sirolimus analogue (ABT-578, Abbott Laboratories, Abbott Park, Illinois) eluting from a cobalt chromium Endeavor stent (Medtronic, Santa Rosa, California). Procedural success was 100%; 30-day major adverse cardiac event (MACE) rate was 1% while four-month angiographic late loss was 0.33 mm.

**SCRIPPS-IV.** Scripps Radiation to Inhibit Proliferation Post Stenting. Paul S. Teirstein, MD.

The SCRIPPS-IV investigators compared 14 Gy (standard dosing) versus 17 Gy (21.4% higher dose) gamma radiation to assess additional efficacy of the higher dose on restenosis in 358 patients with in-stent restenosis. The higher dose resulted in eight-month angiographic in-stent restenosis of 26.6% versus 41.8% standard dose (p = 0.01) and in-lesion restenosis of 38.4% versus 46.8% standard dose (p = 0.18). Subset analysis revealed that diabetics had a reduction in TVR from 48% to 17.2% (p = 0.01) with the higher dose and accounted for the entire reduction in TVR for the study population.

**Implications.** TAXUS-IV was the most significant study presented at the TCT meeting. The benefit of the paclitaxel-coated stent in all lesion subtypes and patient populations including diabetics was clinically significant and consistent. Given the results of TAXUS-IV, clinicians will be faced with important questions: Not only should all patients receive a drug-eluting stent (DES), but which one? Both the sirolimus-coated Cypher ( Cordis, Miami Beach, Florida) and paclitaxel-coated Taxus stents have demonstrated dramatic benefits compared to their bare-metal control groups. As TLR rates in various lesion and patient subtypes are in the low single digits with both of these stents, it will be difficult to prove superiority of one stent over the other. Therefore, other stent characteristics including deliverability, visibility, side-branch access, balloon overhang, and cost will become deciding factors in choosing between these stents. In our experience, the Taxus stent is easier to deliver and has greater side-branch access compared to the Cypher stent. However, the Cypher is more visible, and late loss of 0.24 mm in the analysis segment with the Cypher stent (1) is lower than the 0.39 mm with the Taxus stent, which may be relevant in the very small vessels. Pilot studies utilizing ABT-578 and everolimus-eluting stents appear promising, demonstrating low late loss indices. The future availability of new DES should result in significant cost reductions. Therefore, once the major current limitation of utilizing DES in all patients (i.e., cost) is no longer a factor, the criteria determining DES use and selection will become the technically superior product and the company providing better service and research. Further studies utilizing DES in bifurcation lesions, unprotected left main stenosis, acute MI, vein graft disease, long lesions, and restenotic lesions are required. In the meantime, particular caution must be exercised in utilizing DES in very high-risk lesions like left main stenosis where a TLR rate of 19.3% has been reported with the Cypher stent (2).

For healthcare systems in which a DES for every patient is difficult to justify financially, the bare-metal stent group in TAXUS-IV demonstrated that 89% of the PCI population could be effectively treated with bare-metal stents. Newer cobalt chromium stents, such as Vision (Guidant) and Driver (Medtronic), owing to their thinner stent struts, may further lower restenosis compared to stainless steel stents, but randomized clinical trial data are lacking. Brachytherapy remains an excellent treatment option for in-stent restenosis of non-DES. Although, results from the SCRIPPS-IV trial support a higher gamma radiation dose (17 Gy vs. 14 Gy), the applicability of this finding to the current practice of interventional cardiology is limited. As beta-radiation systems are easier to use and maintain, and have comparable results to gamma radiation, practice patterns will continue to favor them.

**ADJUNCTIVE PHARMACOTHERAPY DURING PCI**

Though the recent focus in interventional cardiology has primarily been toward preventing restenosis with DES, efforts have also been directed toward optimizing anticoagulant regimens and improving periprocedural outcomes. The lingering question of glycoprotein (GP) IIb/IIIa inhibitor effect on restenosis, if any, continues to cloud the issue of which antiplatelet and anticoagulant regimen is most efficacious. Studies presented at the TCT meeting confirmed the safety of another anticoagulation regimen for PCI patients and ended the controversy of abciximab's effect on restenosis.

**REPLACE-2 (six-month results).** Randomized Evaluation of PCI Linking Angiomax to Reduced Clinical Events-2. A. Michael Lincoff, MD.

The REPLACE-2 study was a 6,010-patient noninferiority clinical trial in which subjects undergoing elective or urgent PCI (not primary PCI for acute MI) were randomized either to the direct thrombin inhibitor bivalirudin plus provisional abciximab or eptifibatide (used in 7.2% of patients) or to heparin plus a GP IIb/IIIa inhibitor (abciximab or eptifibatide). The primary quadruple composite end point of the 30-day incidence of death, MI, urgent repeat revascularization, or in-hospital major bleeding was observed in 9.2% of the bivalirudin group and 10.0% of the heparin plus GP IIb/IIIa inhibitor group (p = 0.32) (3). However, the bivalirudin group had a nonsignificant higher rate of MI at 30 days (7.0% vs. 6.2%, p = 0.23) but with a reduction in major bleeding events (2.4% vs. 4.1%, p < 0.001).

Six-month data from REPLACE-2 demonstrated that the rates of death (0.95% vs. 1.35%, p = 0.15), MI (8.2% vs. 7.4%, p = 0.24), revascularization (12.1% vs. 11.4%, p = 0.45), and TVR (9.8% vs. 8.7%, p = 0.15) were similar in the bivalirudin versus heparin plus GP IIb/IIIa arms, respectively.
**RCTS.** A Prospective, Randomized Multicenter Trial of Cilostazol vs. Ticlopidine in Patients Undergoing Stent Implantation. Jumbo Ge, MD.

Cilostazol is a platelet aggregation inhibitor shown to reduce neointimal proliferation and possibly restenosis. The investigators randomized 397 patients to either ticlopidine 250 mg twice a day for one month or cilostazol 100 mg twice a day for six months after elective coronary stenting to evaluate the effect of cilostazol on restenosis. The primary end point of angiographic restenosis at six months was 29.1% in the cilostazol group and 36.6% in the ticlopidine group (p = 0.086).

**ISAR SMART-II.** A Prospective, Randomized Four-arm Trial of Phosphorylcholine-coated Stenting ± IIb/IIIa Inhibition vs. PTCA ± IIb/IIIa Inhibition in Patients with Small Coronary Arteries Undergoing PCI. Adnan Kastrati, MD.

The investigators, utilizing a 2 × 2 factorial design, randomized 502 patients with small coronary arteries (<2.5 mm) to a phosphorylcholine-coated BiodivYsio SV stent (Abbott Vascular, Redwood City, California) versus balloon angioplasty, and abciximab versus placebo, to determine the effect of this stent and abciximab on restenosis in small coronary arteries. Patients were pretreated with clopidogrel, and the groups were matched for baseline clinical and angiographic characteristics (average vessel diameter 2.2 mm and 28% diabetics). The primary end point of angiographic binary restenosis was 39.0% with stenting and 34.2% with balloon angioplasty, and abciximab versus placebo, to determine the effect of this stent and abciximab on restenosis in small coronary arteries. Patients were pretreated with clopidogrel, and the groups were matched for baseline clinical and angiographic characteristics (average vessel diameter 2.2 mm and 28% diabetics). The primary end point of angiographic binary restenosis was 39.0% with stenting and 34.2% with balloon angioplasty (p = 0.30) at six months, while TVR was 20.9% and 21.3% (p = 0.93), respectively. Abciximab failed to reduce angiographic restenosis (39.3% abciximab vs. 34.3% placebo, p = 0.29) or TVR (19.9% abciximab vs. 22.3% placebo, p = 0.51). Secondary end points of one-year TVR, death, or MI were not favorably affected with either stenting or with abciximab.

**Implications.** The six-month results of REPLACE-2 are reassuring in that the higher periprocedural MI rate with bivalirudin does not lead to an increased six-month mortality. The absence of a significant difference in revascularization rates between the two groups, in both diabetic and non-diabetic patients, confirms the absence of GP IIb/IIIa inhibitor effect on restenosis. It is important to note that in REPLACE-2, patients with an acute coronary syndrome treated with heparin or upstream GP IIb/IIIa inhibitor were excluded, and 86% (5,159/6,002) of the study cohort were pretreated with either clopidogrel or ticlopidine. Therefore, the noninferiority of bivalirudin (with bailout GP IIb/IIIa inhibitor) against heparin plus GP IIb/IIIa inhibitor, at 30 days and six months, is only proven for stable patients undergoing PCI who have been pretreated with clopidogrel or ticlopidine.

Results from the ISAR SMART-II trial demonstrate that at least in the presence of clopidogrel pretreatment, there was no demonstrable benefit to abciximab or bare-metal stenting on angiographic restenosis, TVR, or 30-day MACE rates in small vessels. Given the high restenosis rates observed with balloon angioplasty and bare-metal stents, studies are needed to determine whether small coronary arteries are best treated with DES. The trend toward lower restenosis with cilostazol in the RACTS trial suggests that a larger study may be required to answer the question of cilostazol’s effect on neointimal proliferation and restenosis.

**ACUTE MYOCARDIAL INFARCTION**

A meta-analysis of 23 randomized clinical trials of primary PCI versus thrombolysis for the treatment of acute ST-elevation MI (STEMI) concludes that primary PCI is superior in terms of death (7% vs. 9%, p = 0.0002), nonfatal reinfarction (3% vs. 7%, p < 0.0001), and stroke (1% vs. 2%, p = 0.0004). However, primary PCI cannot be offered to every patient owing to the low number of high-volume operators and primary PCI centers. Because significant myocardial necrosis occurs even with early primary PCI, current efforts are being directed to evaluate adjunctive techniques of myocardial salvage.

**COOL-MI.** A Prospective, Randomized Trial of Mild Systemic Hypothermia During PCI Treatment of ST-Elevation MI. William W. O’Neill, MD.

This trial tested the safety, efficacy, and ability to enhance myocardial salvage of systemic patient cooling as an adjunct to primary PCI for STEMI. The investigators randomized 392 patients with anterior or inferior (with reciprocal changes) STEMI of <6 h duration to either primary PCI or primary PCI with endovascular cooling (Radiant Medical, Redwood City, California) produced by a 10F endovascular catheter placed in the inferior vena cava. The two groups were matched in baseline clinical and angiographic characteristics except that door-to-balloon times were higher in the cooling group (110 vs. 92 min, p = 0.003). Cooling was tolerated in 94.3% of the cohort, although buspirone and meperidine were required to control shivering. Analysis revealed no difference in left ventricular infarct size (14.1% cooling vs. 13.8% control, p = 0.83) or 30-day MACE rates (6.2% cooling vs. 3.9% control, p = 0.45) but did observe an increased risk of shock in the cooling group (12.4% cooling vs. 6.1% control, p = 0.06).

**X-AMINE ST.** X-Sizer in Acute Myocardial Infarction Patients for Negligible Embolization and Optimal ST Resolution. Thyeri Lefevre, MD.

Intracoronary thrombus with distal embolization is thought to be partly responsible for no-reflow and poor microvascular perfusion after primary PCI for STEMI. This study evaluated the benefit of mechanical thrombectomy with the X-Sizer catheter (ev3, Plymouth, Minnesota) before primary PCI. Investigators randomized 201 patients with STEMI of <12 h in whom initial angiography demonstrated TIMI 0/1 flow grade in a native coronary artery. Baseline clinical and angiographic characteristics, GP IIb/IIIa inhibitor use, and stent use were the same in both groups. The primary end point of
ST-segment resolution was greater in the thrombectomy group (7.5 mm vs. 4.95 mm, p = 0.036). Secondary end point analysis revealed less slow flow/no-reflow (4.1% vs. 16.0%, p = 0.012) and distal embolization (2.1% vs. 10%, p = 0.006) in the thrombectomy group but with the addition of procedural time (55 vs. 45 min, p = 0.003). Interestingly, no differences in the final infarct artery TIMI frame count, percentage of patients with final TIMI-3 flow grade, or 30-day MACE rate between the two groups were noted.

**ON-TIME.** Ongoing Tirofiban in Myocardial Infarction Evaluation. **Harry Suryapranata, MD.**

Prehospital treatment of STEMI with the GP IIb/IIIa inhibitor abciximab results in greater TIMI-3 flow at initial angiography, and improved 30-day left ventricular function and six-month clinical outcomes (5). This study evaluated the benefits of early precatheaterization initiation of the GP IIb/IIIa inhibitor tirofiban against late in-laboratory initiation, as an adjunct to primary PCI for STEMI. The investigators randomized 507 patients with STEMI of <6 h undergoing primary PCI to early (ambulance or referral center) or late (cardiac catheterization laboratory) tirofiban. The two groups were matched for baseline characteristics, and the primary end point of TIMI-3 flow at initial angiography was noted in 19% of the early group and 15% of the late group (p = 0.22). Secondary end points of visible thrombus at initial angiography (25% early vs. 32% late, p = 0.06) and PCI success as judged by postprocedural TIMI-3 flow, myocardial blush scores, and corrected TIMI frame counts were also similar between the two groups.

**Implications.** Though tremendous hope had been placed on systemic hypothermia as a useful adjunct to limit infarct size, the results of COOL-MI are disappointing. Despite randomizing patients with large infarcts only, the investigators were unable to demonstrate benefit of this therapy. The inability to cool all patients to 33°F, as was the goal, may have been one limitation to the potential benefit of this therapy. Hyperbaric oxygen, by inhibiting leukocyte adherence, reducing tissue edema, limiting lipid peroxidation, and free radical formation, has been shown to reduce tissue injury associated with ischemia/reperfusion (6). Studies are ongoing to evaluate the benefit of intracoronary hyperemic blood delivery after primary PCI for STEMI, and preliminary data regarding infarct size reduction appears more promising than endovascular cooling.

Mechanical thrombectomy with the X-Sizer catheter led to greater ST-segment resolution, lower incidence of distal embolization, and no-reflow, but this did not translate to a lower 30-day MACE rate. This last finding is disappointing and raises the question of routine use of this device for all STEMI patients. Limiting this device to patients with a large thrombus burden may translate the initial angiographic benefits of this device into clinical benefits. Though the failure of early administration of tirofiban for STEMI may be related to a suboptimal dose of tirofiban, the ON-TIME study does not support substantial benefit of early tirofiban initiation for STEMI.

**PERIPHERAL VASCULAR DISEASE**

Newer therapies and controversies regarding peripheral vascular disease (PVD) treatments were discussed, and one-year results of an important clinical trial regarding carotid stenting were presented.

**SAPPHIRE (one-year results).** Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy. **Jay Yadev, MD.**

This multicenter study randomized 310 high-risk surgical candidates to carotid stenting with the nitinol self-expanding Precise stent (Cordis) in conjunction with Angioguard (Cordis) distal embolic protection versus carotid endarterectomy (CEA). Symptomatic patients with a greater than 50% internal carotid artery stenosis, or asymptomatic patients with a greater than 80% stenosis with all patients having at least one high-risk co-morbidity for CEA, were randomized. The primary end point of 30-day major adverse event (MAE = death, MI, and any cerebrovascular accident [CVA]) has been reported previously and was 5.8% with stenting and 12.6% with CEA (p = 0.047).

The secondary end point of 30-day MAE plus death and ipsilateral CVA between 1 and 12 months was 11.9% with stenting and 19.9% with CEA (p = 0.048). No differences in mortality or MI were seen at one year, but lower rates of major ipsilateral stroke were noted after stenting. Clinically driven TLR occurred in 0.6% of patients with stenting versus 4.0% with CEA (p = 0.06), while cranial nerve injury occurred in 0.0% with stenting versus 4.6% with CEA, (p = 0.006).

**Implications.** The SAPPHIRE trial demonstrates the noninferiority of carotid stenting to CEA for patients with carotid artery stenosis and high-risk surgical features. The Carotid Revascularization Endarterectomy versus Stent Trial (CREST) is a NIH/Guidant-funded study that is randomizing 2,500 low-risk patients to evaluate these two strategies for carotid revascularization. Until the results of the CREST trial are available, patient and physician preference is likely to dictate carotid stenting as the preferred modality of carotid artery revascularization for patients with high-risk surgical features once reimbursement issues regarding this procedure are settled.

The treatment and limitations associated with endovascular approaches to noncarotid PVD were discussed in numerous sessions devoted to the subject. Iliac and subclavian artery stenoses can be treated by endovascular techniques with excellent short- and long-term outcomes. However, significant investigational efforts are ongoing to determine the optimal revascularization strategy for superficial femoral artery (SFA) disease. It has been suggested that nitinol, as opposed to stainless steel self-expanding stents, has lower restenosis in the SFA. However, reports of late stent fractures with nitinol stents in this vessel exist.
The clinical implications of this latter finding are unknown, and future clinical trials with DES in the SFA are underway, which will help address the issue and also determine restenosis rates with DES in the SFA. Percutaneous treatment of infrapopliteal disease is primarily utilized for limb salvage and as an adjunct for the treatment of nonhealing ulcers in the lower extremities.

Percutaneous stent placement (not balloon angioplasty) with 98% success and 2% complication rate is the treatment of choice for renal artery stenosis. Though renal artery stenosis is a progressive disease and is associated with increased mortality in the presence of chronic renal insufficiency, no well-designed clinical studies have proven that treatment of a stenotic renal artery reduces mortality. Nevertheless, acceptable indications for renal artery stenting include bilateral renal artery stenosis with hypertension, unstable angina, progressive renal insufficiency, or recurrent pulmonary edema; or unilateral renal artery stenosis in hypertensive patients with >70% stenosis, a kidney larger than 7 cm, and a resistive index <0.8 by Duplex ultrasound. The future role of DES and distal embolic protection devices for renal artery stenting remains to be defined.

NEW DEVICES/TECHNIQUES/THERAPIES

Complex issues regarding newer techniques and devices for treatment of the coronary vasculature, peripheral vasculature, and structural heart disease were discussed.

Complex Coronary Anatomy

Bifurcation lesions. The treatment of a bifurcation lesion has been a long-standing problem in interventional cardiology and remains difficult. A significant portion of the live case demonstrations focused on the treatment of bifurcation lesions using the “Crush Technique” (7), which was demonstrated in multiple cases but was not always successful in the hands of these high-volume operators. This technique involves the placement of a DES in the side-branch vessel and this stent is pulled back at least 4 to 5 mm into the parent vessel at the time of deployment (Fig. 1). The side-branch stent balloon and wire are then removed. A second DES is then deployed in the parent vessel and it crushes the proximal 4 to 5 mm of the side-branch stent, which is in the parent vessel. At this point, only if the angiographic images in multiple projections reveal an unacceptable result, the side-branch stent is recrossed, and kissing balloon inflations are performed. Theoretically, this technique ensures that a DES covers the entire diseased segment in the parent vessel and side-branch. However, it is not always easy to recross into the side-branch with three layers of stent that have been opposed against the vessel wall. Furthermore, the potential toxicity of the eluting drug at three times the recommended dose is unknown, and, most importantly, no long-term data regarding the efficacy of this approach were presented.

Figure 1. Crush technique: stent positioning. The proximal marker of the side-branch stent (thin dashed line) must be situated in the main branch at a distance of 4 to 5 mm proximally to the carina of the bifurcation. Thick dashed line follows the main-branch stent. Adapted from Colombo et al. (7) with permission.

Chronic total occlusions. Suero et al. (8) have reported on the long-term benefits of recanalizing chronic total occlusions (CTOs). Of the various devices and techniques presented, the FrontRunner (Lumend, Redwood City, California) catheter seemed to be a particular favorite of multiple operators and successfully utilized for CTOs in both coronary arteries and peripheral vessels. It is a blunt microdissection tool that requires careful dissection into the distal true lumen from the proximal true lumen. Although the device is approved by the U.S. Food and Drug Administration (FDA), it should be reserved for situations in which other techniques have failed.

Structural Heart Disease

Percutaneous mitral valve repair/annular reshaping. Percutaneous mitral valve repair involves placement of stent-like devices in the coronary sinus that reshape and tighten the mitral valve annulus by pushing the posterior leaflet anteriorly. The risk of impinging on the circumflex coronary artery and thrombosis of the coronary sinus with this device is unknown. Another approach presented was the percutaneous suture of the mid-portions of the anterior and posterior leaflets of the mitral valve, creating a double-barreled orifice of the valve. Animal studies with these devices appear promising.

Percutaneous aortic valve replacement. This technique has been described previously (9), and clinical data from the initial series were presented. Seven patients with critical aortic stenosis, who were nonsurgical candidates owing to co-morbid conditions, had a bovine bioprosthetic valve mounted on a specially designed stent (Percutaneous Valve Technologies, Fort Lee, New Jersey), which was placed anterogradely in the aortic valve position. Though paraval-
vular aortic regurgitation was noted in some patients, all patients had a mean transvalvular gradient of 5 mm Hg 24 h after the procedure with a reduction in valvular stenosis and an improvement in ejection fraction. The technique requires further refinement but appears promising.

**Patent foramen ovale closure.** The primary limitation for widespread patent foramen ovale (PFO) closure is the paucity of data demonstrating the efficacy of this approach. Currently, PFO closure can be carried out as a humanitarian device exemption for patients who suffer a recurrent cryptogenic stroke despite anticoagulation therapy. Large randomized clinical trials are finally underway that will compare outcomes of PFO closure against standard medical therapy in patients who suffer a first-time cryptogenic stroke.

**Adjunctive Interventional Devices**

**Atherectomy devices.** The X-Sizer Thrombectomy Catheter (ev3) is a disposable device designed to rotate, cut, and aspirate thrombotic material but is not FDA approved. For femoral-popliteal and infrapopliteal disease, the SilverHawk System (FoxHollow Technologies, Menlo Park, California) is an FDA-approved device for de novo and restenotic lesions in the lower extremities. The catheter is placed in the diseased segment and with activation of the cutter, plaque is removed and collected in the distal cone of the device. Both calcified and noncalcified lesions in peripheral vessels 2 to 6 mm in diameter can be treated. Studies utilizing this device in the coronary vasculature are ongoing.

**Percutaneous hemodynamic support.** For patients in cardiogenic shock who require PCI, or in patients with or without left ventricular dysfunction who have only one patent vessel and require PCI, intracoronary balloon pump counterpulsation is the most commonly used assistive device. The Impella® acute (Impella, Aachen, Germany) is a 12F left ventricular system that is inserted percutaneously via a 13F sheath in the femoral artery and has both a proximal and distal port positioned within the proximal aorta and left ventricle, respectively. It actively unloads the left ventricle, enables a cardiac output of 2.5 l/min, can be left in place for five days, and could be utilized for acute MI, cardiogenic shock, high-risk PCI, and a low output cardiac state. It is not yet FDA approved.

**Vulnerable plaque detection.** Invasive modalities to detect vulnerable plaque include the following: a thermography catheter that is temperature sensitive and can detect higher temperature plaques which may be vulnerable to rupture; intravascular ultrasound with differential measurement of tissue echogenicity; intravascular ultrasound palpography, which can determine ultrasonic backscatter from hard and soft plaque, thus enabling assessment of plaque strain; and optical coherence tomography. Though all of these invasive modalities appear useful, noninvasive modalities including biomarkers, or computed tomography/magnetic resonance imaging that could identify the vulnerable patient rather than plaque, seem more attractive.

**Distal embolic protection devices.** Most of the newer generations of distal embolic protection devices are able to capture both micro- and macro-particulate material while enabling blood flow at the time of PCI. It is becoming increasingly clear that saphenous vein graft interventions, native coronary artery interventions in both acute MI and acute coronary syndromes, carotid stenting, and possibly renal stenting should all be performed with distal embolic protection devices.

**Myogenesis/Angiogenesis**

Various strategies for stem-cell implantation to help in preservation and restoration of MI and treat myocardial ischemia were presented. Autologous stem-cell injections are feasible, and stem cells can be injected intravenously, into the culprit coronary artery three to five days after MI, and epicardially or transcendocardially into the myocardium, with demonstration of homing of these cells to sites of injury (10). Skeletal myoblasts may lead to unorganized muscle cell formation and serve as a source of reentry and ventricular arrhythmias. Though proof of principle has been demonstrated, extensive work is still required to evaluate concentration of stem-cell infusion, route of injection, methodology of gauging success, and evaluation of safety.

**SUMMARY**

The results of several clinically relevant new trials and systematic overviews of current challenges facing interventional cardiology were presented at the TCT meeting. Drug-eluting stents have revolutionized the field of interventional cardiology, and restenosis, though not eliminated, is now at an acceptable level. Adjunctive therapies, both mechanical and pharmacologic, for myocardial salvage during PCI for acute coronary syndromes require ongoing investigative effort. Percutaneous treatment of peripheral vascular disease is in evolution, but in addition to improvement in technology, indications for treatment need to be better defined. Stem-cell treatment of acute and chronic myocardial ischemia and percutaneous strategies for the treatment of structural heart disease appear promising. Although many live procedures were presented, the benefit of live case demonstrations at interventional cardiology meetings is becoming less clear. In the early days of this discipline, live demonstrations were often the only route of exposure to new approaches and techniques. Currently, interventional cardiology is a mature specialty with broad diffusion of knowledge, accredited training programs and a specialty requiring a board examination for certification. Therefore, future presentations of new techniques in the form of live demonstrations will need a clear rationale and should likely be confined to procedures for which clinical efficacy has been established.
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REFERENCE