

## INTERVENTIONAL CARDIOLOGY

# Miracor Medical Systems GMBH

## *Intermittent coronary sinus occlusion to improve post-PCI perfusion*

For nearly three decades, the standard of care for heart attack patients has been percutaneous coronary intervention (PCI), using a balloon or stent to open blocked arteries and restore blood flow. While restoring the flow improves heart function, it doesn't automatically salvage all of the tissue damaged during the heart attack, nor does it address tissue damaged during the reperfusion process itself.

Roughly 25% of PCI patients end up with suboptimal microcirculation of coronary blood flow at six months, even those with a perfectly placed stent and excellent epicardial flow. Longer term, these patients face the risk of additional cardiovascular events or heart failure.

What if there was a way to improve circulation to the damaged areas, as well as reduce the size of infarct or tissue necrosis from the border zone of the ischemic territory? **Miracor Medical Systems GMBH** aims to do just that. Its *PICSO* (*Pressure-controlled Intermittent Coronary Sinus Occlusion*) technology utilizes a balloon inserted into the coronary sinus, the large vessel that drains the coronary arteries. The balloon is intermittently inflated to block venous outflow from the heart. The resulting rise in pressure redistributes blood in the myocardium, where the company believes it will regenerate damaged tissue and lead to improved outcomes for patients.

"More than 75% of the blood flow empties through the coronary sinus, from the myocardium of the heart," says company

CEO Jon H. Hoem. "When we inflate the balloon, the pressure in the coronary sinus—and therefore also in the myocardium—will increase to a pressure plateau." This pressure buildup redistributes flow into the border zone of the ischemic territory, which is the therapeutic effect Miracor is seeking. "Rather than pumping, we are blocking outflow very effectively and safely," Hoem states.

Furthermore, when that pressure plateau is reached, the balloon is deflated, with the intent of achieving some "washout" of emboli clearing the myocardial microcirculation after having occluded the coronary sinus.

The number of patients who are treated for acute coronary syndrome (ACS) but who have suboptimal microcirculation is in excess of 400,000 patients annually worldwide, with a market cap exceeding \$1 billion. Miracor anticipates a CE mark for its technology in the second or third quarter of 2010, followed by FDA approval (likely PMA) for on-label use for infarct-size reduction in 2013 or 2014.

Flash back to 1979, when company founder Werner Mohl, a professor of cardiac surgery at the Medical University of Vienna, attended a presentation in Vienna on retroperfusion, or how arterial blood could be forced into the venous circulation as a technique to regenerate the heart muscle. "Dr. Mohl thought immediately that this was counterintuitive," Hoem says. "By researching the literature, Dr. Mohl determined that it would be much better to just block the native venous blood flow to achieve the same

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**Contact:** Jon H. Hoem, CEO  
**Business:** Devices to improve myocardial perfusion and heart function following PCI  
**Founded:** May 2008  
**Founder:** Werner Mohl, MD, PhD, Chief Scientific Advisor  
**Employees:** 6  
**Financing to Date:** €6 million  
**Investors:** Thom Rasche (Earlybird Venture Capital); Joey Mason, MD (Delta Partners)  
**Board of Directors:** Werner Mohl; Thom Rasche; Marion Jung (Earlybird Venture Capital); Joey Mason; Jon H. Hoem

effect: redistribution of flow into the ischemic territory. Since then, preclinical and clinical studies have been completed—all providing support for the *PICSO* technology and the potential clinical benefits."

Hoem himself has more than 20 years of experience in advanced medical device development and international sales and marketing in cardiology and cardiac surgery. For over a decade, from 1994 to 2005, he was with MediStim, a Norwegian medical device start-up, focusing on quality assurance of coronary bypass procedures and implementing the joint venture with Medtronic Inc. to launch MediStim's products in the US. Afterward, Hoem joined US-based AtriCure Inc. and introduced its cardiac surgery devices for atrial fibrillation in Europe.

Miracor has seven *PICSO* patents (three pending, four issued) and does not share royalties/revenues with any other entity.

The flagship product is the *PICSO Impulse* system, named after its impulse to revive cardiac tissue. The two major components are a console and a single-use catheter. The access point is either the groin or neck, on

the venous side of the heart. A guide sheath or guidewire directs the interventional cardiologist into the right atrium of the heart and into the coronary sinus. These guiding tools are then used to place the *PICSO Impulse Catheter* into the coronary sinus. Correct placement is verified by two radiopaque markers that also identify the location of the expandable *PICSO* balloon that intermittently occludes the coronary sinus.

Insufficient microcirculation can be assessed by suboptimal myocardial blush, which is an angiographic measurement taken immediately following PCI. Suboptimal myocardial blush is directly related to major cardiovascular events (MACE) and patient survival rates. "This will be the decision point as to whether the cardiologist will use *PICSO*," Hoem says. The proprietary "Wien Algorithm" is included with the console to calculate the inflation and deflation cycle of the balloon. "This algorithm is based on measurements of the patient's electrocardiogram [ECG] and coronary sinus pressure," says Hoem, who stresses the importance of starting the procedure immediately following PCI in those patients with a poor myocardial blush.

According to current clinical protocols, the procedure commences immediately following PCI. "But you don't need to have the patient in the cath lab during the procedure. You can relocate him to a holding area," Hoem says. The actual procedure takes 90 minutes.

Whereas most arterial retroperfusion concepts have failed to reach commercialization, other techniques have been tried to substantially improve perfusion in the microcirculation. The closest competitor,

according to Hoem, is US-based **TherOx Inc.**, which earlier this year was unsuccessful in obtaining PMA clearance for its SuperSaturated Oxygen (SSO2) therapy for patients undergoing PCI for anterior acute myocardial infarction (AMI), consisting of delivering oxygenated arterial blood to the arterial bed to enhance microcirculation and reduce infarct size. "The PMA panel refused the application mostly due to the fact that this therapy did not achieve the end point of a 5% mean reduction in infarct size and a higher complication rate," Hoem notes. "I suspect, though, that TherOx will seek FDA clearance again."

The first human clinical study of the *PICSO Impulse* system is scheduled to begin in Vienna near the end of this year. Following this 20-patient, nonrandomized safety trial, Miracor will initiate one study to document improvement in collateral flow and one larger single-center randomized trial. Then, around next summer, the product should start selling in Europe. German-speaking markets and the United Kingdom will be served by a direct sales force, while independent distributors will handle the remaining European markets. Pricing has yet to be determined and a new reimbursement code will need to be generated, beginning in Germany. "Given solid clinical data, the reimbursement process will be easier, yet require the normal processes," Hoem says.

Miracor has raised €6 million (\$9.4 million) to date from Earlybird Venture Capital and Delta Partners. Hoem expects to augment that with another round of financing in late 2010, in the amount of \$10 to \$15

million. "We want to build strong strategic partners on the clinical side in the US, and on the sales and marketing side in the US and Japan," he says.

Future applications of *PICSO* technology will focus on heart failure and cardiac surgery. "We believe that *PICSO* can help both ischemic and non-ischemic heart failure patients," Hoem says. "And in cardiac surgery, retrograde perfusion is already well established in around 20% of patients. We also believe that *PICSO* technology can be used during beating heart coronary bypass procedures. However, the cardiac surgery market segment is relatively small compared with the ACS and heart failure market segments, so we will not enter cardiac surgery in the short term."

Meanwhile, Miracor is focused on improving the inflate/deflate algorithm of its catheter and making it easier for interventional cardiologists to access the coronary sinus. "I've never been affiliated with a company where I've met so many key interventional cardiologists and customers eagerly awaiting a technology that can address this need," Hoem conveys. "Clearly, primary PCI alone is not enough to eliminate the risk for future cardiovascular events. Yet, paradoxically, the process of restoring coronary blood flow can in itself exacerbate a myocardial injury. We look at this as a great opportunity to pursue a segment of the market that currently does not appear to have direct competition."

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—BOB KRONMYER