Rotational angiography supports delicate procedures in transcatheter pulmonary valve placement in an adult and repair of coarctation of the aorta in an infant.

X-ray imaging techniques using GE Innova® image guided system enhance procedure planning, device implantation, and post-procedure assessment.
About the physician

Evan Michael Zahn, M.D., and colleagues in the Cedars-Sinai Medical Center Congenital Heart Program include 3D rotational angiography and Innova HeartVision among their tools for treating congenital heart disease in patients of all ages.

Rotational angiography enhances fluoroscopic imaging by creating a 3D reconstructed model of the anatomy of interest using images from real-time 2D imaging. The image data is acquired in a 5-second, 200-degree gantry rotation and is used to create a 3D reconstructed model of the anatomy of interest on the AW Workstation. The Cedars-Sinai team is also exploring the use of Innova HeartVision software to fuse the acquired reconstructed 3D model to the fluoroscopic images acquired in real-time, enhancing visualization of the complex anatomy characteristic of congenital heart patients.

They use these tools on an Innova IGS 620 biplane X-ray system from GE Healthcare to help treat a growing list of conditions, including pulmonary artery stenoses, coarctation of the aorta, and defects of the right ventricular outflow tract. “The complexity and variability of the outflow tract is truly astounding, but 3D rotational angiography now helps simplify those cases,” says Zahn.

“3D rotational angiography has great utility in treating congenital heart patients. Congenital heart disease is very complicated – there are limitless ways in which the heart can be defective and be repaired. Until recently, we were left in the cath lab with using fairly simple 2D angiograms to sort out very complicated 3D problems. Then, once we sorted out and treated those problems, we were left to assess the results of 3D interventions in two dimensions. 3D allows us, after a certain learning curve, to assess complex 3D structures in their natural 3D state. That affords the potential to diagnose in ways we hadn’t thought of before.”

He observes that 2D angiography does not clearly delineate the courses of different vessels and the relationships among structures. Seeking the best way to profile a lesion can mean performing multiple angiograms and dosing patients repeatedly with contrast and radiation.

Innova 3D, on the other hand, yields a 3D volume with comprehensive anatomic information on a variety of structures, all from a single contrast-aided exam – with the added benefit of shortening procedure time. “For example, we can image the right ventricle and get comprehensive information on the outflow tract, myocardium, central and branch pulmonary arteries,” says Zahn. “Our views are no longer limited by the hardware. One 3D view I like best is looking at a structure from head to toe, straight down through the patient’s head. We can virtually create that view, and in certain cases it has enabled us to find lesions in patients that may previously have gone undiagnosed, and that required treatment, that we may not have seen in 2D. In addition, the measurements are much more reliable. We’re able to measure much as we do on CT scans, using pixel density.

“I have come to believe that it is important to look at 3D structures in 3D. There is some resistance to this technology because it takes time to learn the injection protocols and pacing techniques. However, there are significant benefits that can help minimize the drawback of a small learning curve, which can be ameliorated with a course, and some exam setup time, which can be minimized once you become proficient. Once you master the technique, the diagnostic accuracy and the new diagnoses you can pick up are invaluable to patients.”

About the facility

Since 1902, Cedars-Sinai Medical Center has been known for providing the highest-quality patient care rooted in the Judaic tradition and devoted to the art and science of healing. An academic medical center with 896 licensed beds, Cedars-Sinai was named to the Honor Roll in the 2013-14 issue of America’s Best Hospitals by U.S. News & World Report, 12 of its specialties, including cardiology and heart surgery, were rated among the finest in the nation. The hospital is served by more than 2,000 physicians in every specialty, 10,000 employees and 2,000 volunteers. The Cedars-Sinai Congenital Heart Program, founded in 2012, provides care for congenital heart defects from fetal diagnostics, through childhood and into old age, up to and including heart transplant.
Case 1: Transcatheter pulmonary valve replacement and stenting in an adult with stenosis and calcification in a right-ventricle-to-pulmonary-artery conduit

Case submitted by: Evan Michael Zahn, M.D.

Patient history
A man in his 20s from India had an initial diagnosis of pulmonary atresia. At age 2.5 months he had undergone a shunt procedure in his home country, and at age 5 a complete repair was performed. By his early 20s, he was experiencing progressive exercise intolerance, difficulty maintaining his weight, and general malaise. He was diagnosed in India with worsening obstruction and calcification of the conduit.

Patient evaluation
After an evaluation at Cedars-Sinai – echocardiography, cardiac MRI and CT, a chest-X-ray, and a physical exam – the clinician confirmed severe homograft stenosis and calcification.

Procedure planning
In the cath lab, the patient’s right heart hemodynamic pressures were measured. An intracardiac echocardiogram (ICE) showed a severely stenotic conduit with a large mobile pieces of calcium moving in and out of the outflow tract. The patient was placed under general anesthesia and a pacing catheter was placed in the right ventricle. After the patient was pre-ventilated with 100 percent oxygen, pacing was initiated at 150 beats per minute and incrementally increased until arterial blood pressure was fell to 55/40 (180 beats per minute).

For the 3D rotational angiogram, the patient received undiluted contrast at 12 cc per second for a one-second X-ray delay and a 5-second gantry spin (total 72 cc) (Fig. 1). The 3D image set was then reconstructed on the AW Workstation in the control room, and quantitative measurements of the conduit were made using cross-sectional images (Figs. 2 and 3).

Procedure guidance
Expansion of a calcified conduit carries a high risk of potentially fatal rupture. The course chosen by the physician was serial dilation, for which accurate measurements from 3D rotational angiography were essential (Fig. 5).

The patient’s conduit was expanded using progressively larger and high-pressure balloons, while intermittent low-contrast-dose 2D angiograms helped the clinician verify that no rupture was occurring. When the conduit had expanded to nearly the ultimate size, a bare metal stent was implanted, followed by a transcatheter pulmonary valve. In evaluating the valve with hemodynamic measurement and 2D angiography, the clinician determined that further expansion would be beneficial; this was accomplished with a single high-pressure balloon.

Procedure assessment
Using post-procedure assessment with a 2D angiogram and ICE, the clinician confirmed that the valve was positioned correctly. The patient had no pulmonary regurgitation, and the ICE showed that the chunks of calcium that had been flipping in and out of the outflow tract were successfully apposed against the vessel wall and no longer intravascular.

Patient outcome
The patient stayed in the hospital for 23 hours. Follow-up echocardiography showed a positive result with a functioning valve and virtually no obstruction or regurgitation. He stayed in Los Angeles for three days and was seen in one clinic follow-up visit. He then returned to India with expectation for significant improvement in symptoms.
Case 2: Angioplasty treatment of a 6-month-old girl with coarctation of the aorta

Case submitted by: Evan Michael Zahn, M.D.

Patient history
A 6-month-old girl had been diagnosed in utero with mild coarctation of the aorta, which was confirmed after delivery. By age 3 months, the coarctation had become aggressive and severe. She was relatively asymptomatic, but her left ventricular function was severely depressed and a very tight coarctation existed. At that time, she underwent surgical repair using end-to-end anastomosis. However, by age 6 months the coarctation had recurred, and she was brought to Cedars-Sina Medical Center.

Procedure planning
The patient was placed under general anesthesia in the cath lab, where a complete hemodynamic study was performed, including several pullback measurements across the coarctation that allowed the clinician to confirm a severe obstruction (pressure gradient as high as 50 mm Hg). A 4-French balloon-tipped pacing catheter was placed into the right ventricle, the heart was paced at 200 beats per minute, and a 3D rotational angiogram was acquired (Fig. 1), from which quantitative measurements were taken (Fig. 2).

Procedure guidance
The 3D model was used to find the optimal angle for imaging of the aortic arch during the intervention. Using Innova HeartVision to fuse the 3D image on the live fluoroscopy (Fig. 3), the clinician performed a serial angioplasty on the aortic coarctation, starting with a 5.5 mm balloon inflated to 13 atmospheres.

Procedure assessment
A final hemodynamic study, 2D angiography, and a 3D rotational acquisition allowed the clinician to confirm that the procedure had been successful (Figs. 5 and 6). The patient’s pressure gradient after the final angioplasty was 5 mm Hg.

Patient outcome
The patient recovered in the hospital overnight without incident and was discharged the next day.
About GE Healthcare

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