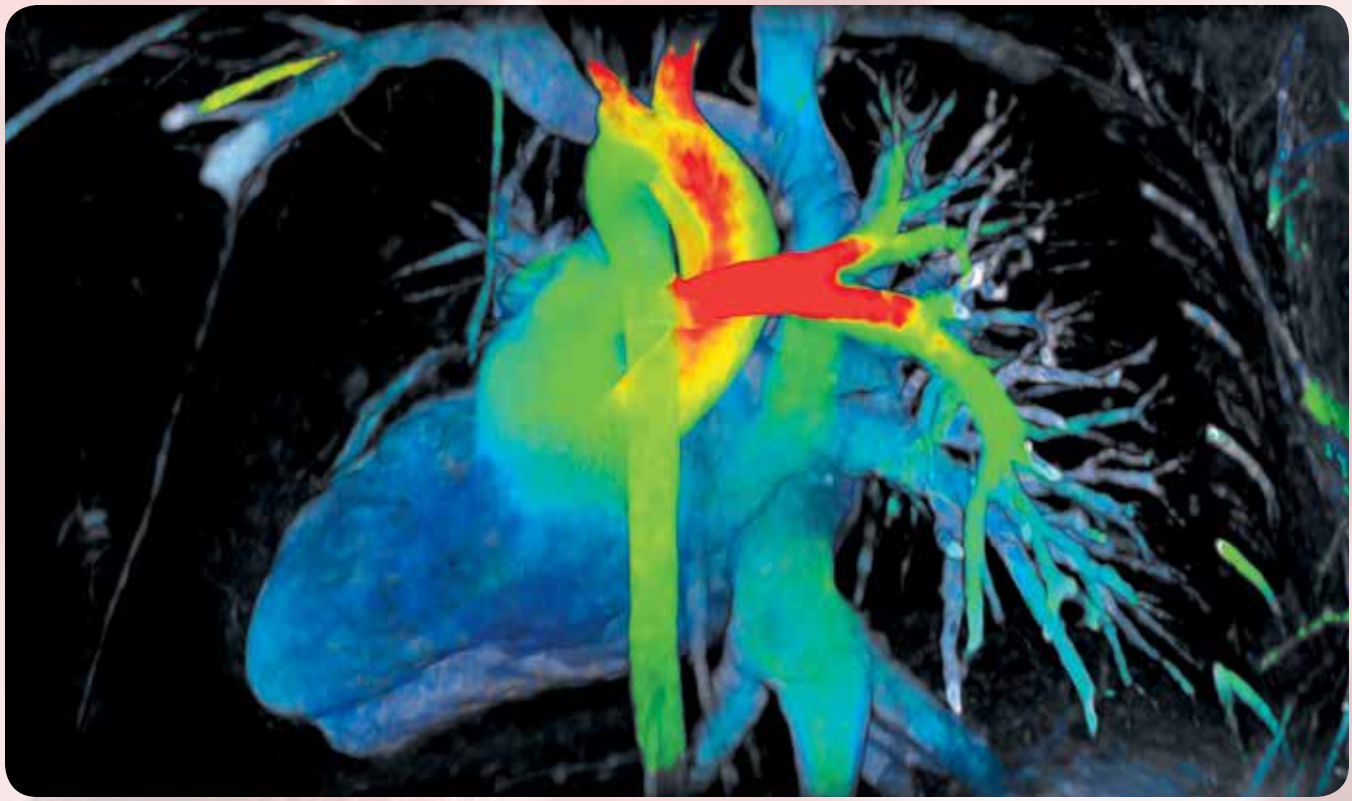

# Go with the Flow

## ViosWorks‡ Can Help Reduce Complexity to Lower Costs and Improve Results in Cardiac MR

On average, conventional cardiac MRI (CMR) exams represent less than 1% of all MR studies performed, and there's good reason for such a miniscule number.[1]

It has historically been very complicated to perform CMR. First, there is the time necessary—often over one hour for the study—due to the procedure's complexity. The diagnostic technique requires the acquisition of multiple sequences, which are primarily 2D and highly specific in scan plane orientation. This means technologists have little margin for error when capturing constantly moving and complex anatomy. As a result, these CMR scans need the support of a subspecialized cardiovascular imager—a unique situation in the MR world, as the majority of procedures can be performed solely by the MR technologist and reviewed later by a clinician.

Putting it all together, the average acquisition time for using a conventional technique is approximately 45 to 60 minutes for flow and function analysis, 60 to 90 minutes for congenital cases (flow, function, and anatomic analysis), and 60 minutes for valvular disease.

"Plus, you're asking patients to do long breath holds," says Fabien Beckers, Chief Executive Officer and founder of San Francisco-based Arterys. "If you have cardiac issues, holding your breath multiple times for 10 or 20 seconds can be tricky to say the least."

‡ ViosWorks is not commercially available at this time.

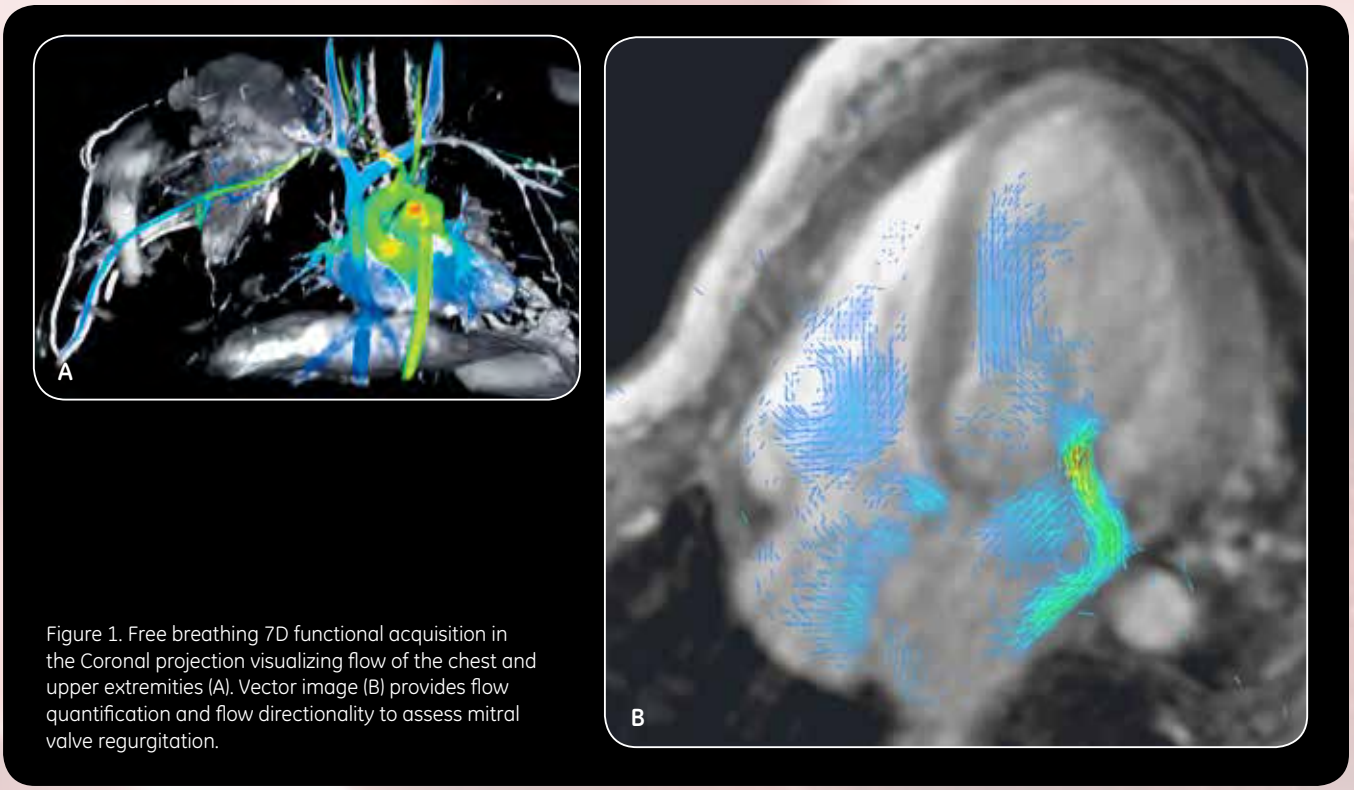


Figure 1. Free breathing 7D functional acquisition in the Coronal projection visualizing flow of the chest and upper extremities (A). Vector image (B) provides flow quantification and flow directionality to assess mitral valve regurgitation.

Beyond CMR, other modalities to assess cardiac flow and function have some drawbacks. "For example, an echocardiogram may be more affordable and thus widely used, but the quality of the exam is highly user-dependent," Beckers adds. "Therefore, it may be hard for a clinician to provide a confident diagnosis as it pertains to blood flow."

Fortunately, there's technology out there that helps alleviate the complexity and cost concerns, all while offering improved results in a shorter amount of time.

## Toward better informed diagnoses and decisions

While not new, the technology behind a multi-dimensional CMR study of flow and function has been relegated to the research arena for much of its history. Now, with recent technological advances and the collaboration of GE Healthcare and Arterys, clinicians will have access to ViosWorks, a 7D Flow CMR study that can be completed between 10 and 20 minutes—without breath holds.

ViosWorks encodes anatomic and velocity information for every location in an entire imaged volume and at every time point in the cardiac cycle. Specific localization is no longer necessary, and the promise is that a cardiovascular imager may not need to be present at the scanner to supervise the MR technologist.

ViosWorks' strength is in its speed and simplicity, says Anja Brau, manager of Global Cardiac MR Applications at GE Healthcare. "All you need to know is where the chest is on the patient. For the technologists, ViosWorks is very easy to adopt, as they don't need to know detailed abnormal cardiovascular anatomy."

One big issue should be kept in mind, though. The resulting images can be extremely large (at least 5 GB) since files include magnitude (anatomic) data over several cardiac phases (i.e., 20 time points) and corresponding data for each of the three flow directions.

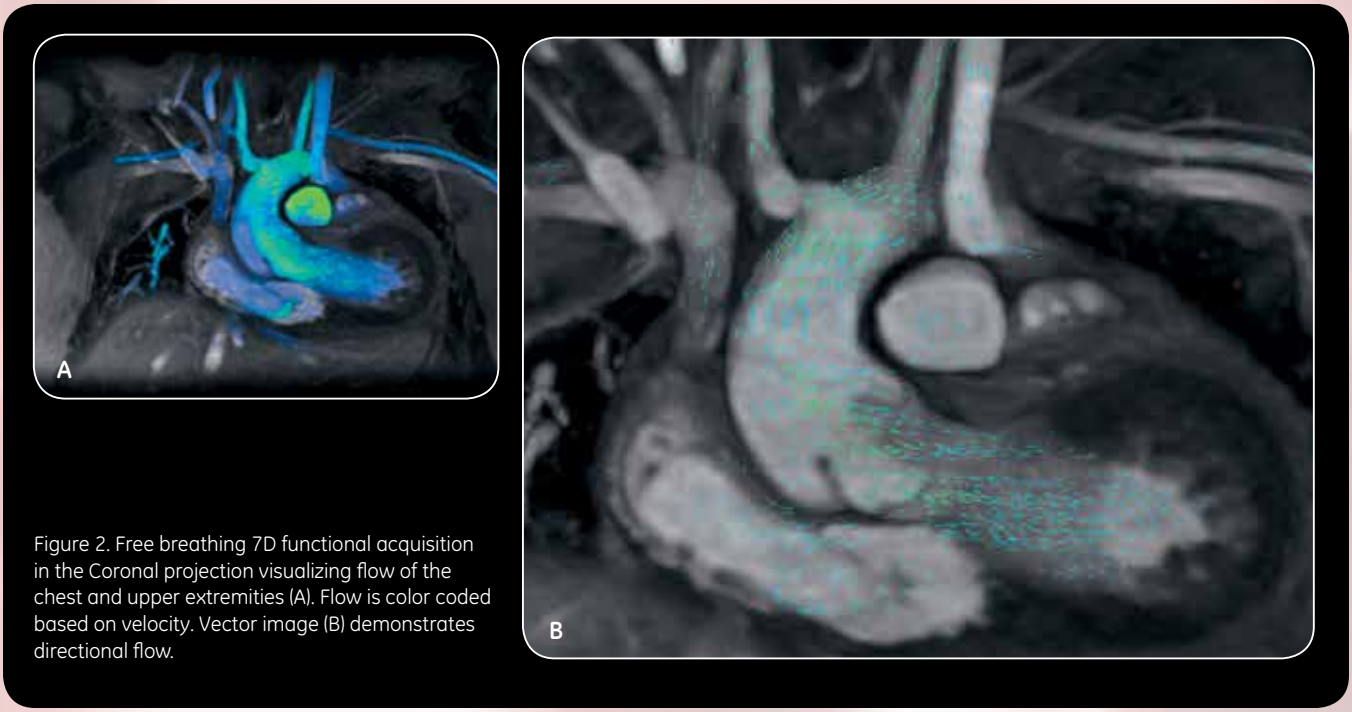


Figure 2. Free breathing 7D functional acquisition in the Coronal projection visualizing flow of the chest and upper extremities (A). Flow is color coded based on velocity. Vector image (B) demonstrates directional flow.

"That's where Arterys comes in," says Brau.

The company has created a high-performance GPU cloud platform that can operate at scale in a high-demand environment and process large flow datasets reliably, accurately, and at a cost savings to healthcare systems. This enables clinicians to acquire highly accurate data and extract flow information. This can be used to drive patient management to help improve outcomes with timely intervention, advance overall quality of care, and enhance hospital profitability—with no additional hardware.

Through cloud delivery, hospitals, and interdisciplinary care groups, including primary care physicians, radiologists, cardiologists, and surgeons, can collaborate effectively and benefit patients. Also, facilities that lack specific expertise can leverage expert opinions at remote institutions in real time.

Beckers compares the cloud to upgrading from a flip phone to a smart phone. "Everything used to be local at the machine level and routed through the hospital network to be visualized," he says. "Now, we can boost the whole value chain of medical imaging by having access to cloud computation. This opens up the possibility to use machine learning with big data to offer automatic quantification, data analytics, and predictive analysis which can make a profound impact to heathcare. That's what makes the difference."

## Flow accuracy

With respect to flow accuracy, studies in the *Journal of Magnetic Resonance Imaging*, *Radiology*, and the *American Journal of Roentgenology* have demonstrated ViosWorks' clinical viability and accurate quantification relative to conventional MR techniques. For each case, using the conservation of mass principle (Qp/Qs ratios and comparing ventricular volume displacements), the physician can validate the flow values are consistent.

"ViosWorks can simplify and accelerate current CMR data," Beckers says. "It creates a new use for MR—clinicians have an accurate and efficient way to quantify blood flow in the body."

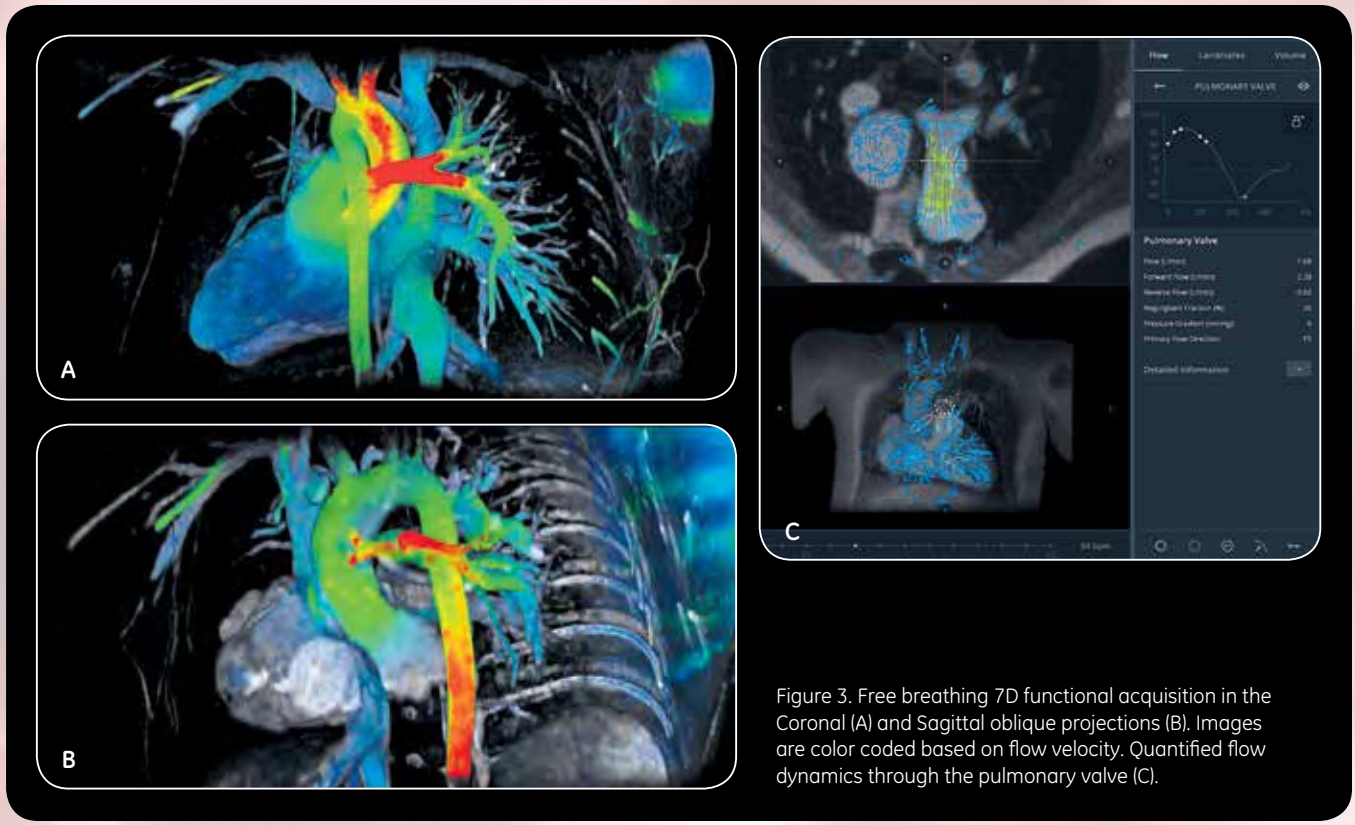


Figure 3. Free breathing 7D functional acquisition in the Coronal (A) and Sagittal oblique projections (B). Images are color coded based on flow velocity. Quantified flow dynamics through the pulmonary valve (C).

With ViosWorks, you can visualize the whole chest and beating heart from any vantage point—any structure in any plane—simultaneously seeing ventricles contracting and accurately quantifying blood flow. Flow velocity is color-coded and overlaid onto the anatomy (see example tiny.cc/spa151).

In terms of clinical applications, ViosWorks can reduce the time it takes to perform viability studies by performing the scan between perfusion and delayed enhancement sequences. A potential impactful application of ViosWorks is congenital heart disease, where it can help reduce the duration, depth, and frequency of anesthesia required for the study.

There is another advantage that is particularly salient for children, and that is the reduction in the use of ionizing radiation. Instead of seeking complementary information to echo by CT, ViosWorks can give comprehensive view in pediatrics, Beckers explains. "It's even more difficult to use echo when you have all sorts of strange shapes with a complex congenital case. Not everything is in place where it should be, and it's very hard for physicians to understand what's going on—let alone quantify flow, which will determine if a child needs an intervention."

Another anticipated common clinical application for ViosWorks will be in assessing valvular disease. Typically, echo is the first-line diagnostic tool. However, ViosWorks enables accurate quantitative flow and function measurements non-invasively and quickly, which drives critical treatment paths, including triage to medical management or surgical intervention.

**DIGITAL DIVE**
View an example of ViosWorks: tiny.cc/spa151

"With ViosWorks, one can calculate flow in the vessel, regurgitation fraction, ventricular values, and ejection fraction," says Brau. "It provides key information the clinician needs for the care decision pathway with a good understanding of the heart's function, so for example, it can be used to help determine if the patient should undergo valve replacement surgery."

"For example, ViosWorks has enabled clinicians to calculate blood flow in the pulmonary circulation (the vessels that supply blood to the lungs). That is not feasible with conventional MR," she says. In one case, the patient required a revision surgery to the pulmonary arteries and ViosWorks provided a road map for the surgeon to perform the repair.

According to Beckers, several surgeons have commented on the initial images and questioned if they are from some new imaging modality. "Once they get over the fact that this is from an MR system, then they realize the images provide such a clear roadmap of the anatomy and structure—for them it becomes easier to picture what they are going to do."

Other possible applications of ViosWorks include evaluation of aneurysms, arteriovenous malformations, portal hypertension, and renovascular disease. The blood flow vectors, quantitative flow and 3D visualization tools enhance pre-surgical assessment and planning capabilities.

## Time benefits

As for the specific time benefits of ViosWorks, Beckers shares two examples. First, for patients with congenital or acquired structural heart disease, the clinical workflow without ViosWorks is 70 minutes of scanner time (function/morphology, 2D-PC, and MRA), along with an additional 30 minutes of clinical processing. With ViosWorks, scanning time can drop by 86% to 10 minutes, with only an additional 20 minutes for image reconstruction, upload to server, processing, and clinical report. So the time can decrease to 30 minutes from 100 minutes.

Second, in patients with myocardial scarring and viability issues, the clinical workflow without ViosWorks is typically 88 minutes of scanner time (function/morphology, 2D-PC, perfusion, wait and delayed enhancement), with a range from 30 to 45 minutes for clinical processing. Scanner time—perfusion, volumetric flow, and delayed enhancement—decreases to 33 minutes (a 61% drop) with ViosWorks. Then, it's only about another 20 minutes for image recon, upload to server, processing, and clinical report. In this scenario, the time drops from approximately two hours to just less than one hour.

The hope is that the healthcare system as a whole can benefit through a direct reduction in imaging costs, due to shorter scan times, as well as savings from delivery of appropriate therapies.

## The patient wins

Most importantly, patients will benefit through having access to a shorter exam and lower-cost technique that can help provide earlier diagnosis and appropriate treatment plans, he notes.

"It's simple and fast, with no radiation," Beckers said. "That's the way we believe it should be."

The patient benefits go beyond the speed and simplicity of the exam. Brou says. "Since the study can be performed so quickly, it can be scheduled in a timely manner to better accommodate the patient schedule. This can push up their surgery so they are not waiting longer in the hospital."

Plus, the patient and family have a much better understanding of what will happen. ViosWorks provides a richer amount of clinical data in a way that people can see and appreciate, Brau says. "Compared to conventional MR, we have the entire anatomy across the chest, including the flow."

Having more information on the disease and anatomy can help the clinician to counsel the patient on options and what to expect, she adds.

"It's like connecting an MR to a supercomputer—this gives us a new way to attack a clinical problem and possibly open up new options for the patient."

**Reference**

1. Magnetic Resonance, A Peer-Reviewed, Critical Introduction. 8th Edition, Version 8.9, April 2015. Available at www.magneticresonance.org/ch/21-01.html. Accessed October 30, 2015.