3D VISUALIZATION SOFTWARE: IS IT READY FOR THE REAL WORLD?

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The radiology community has increasingly been confronted with a surge in the volume of images, making a shift in image interpretation and management inevitable. Indeed, the Society for Computer Applications in Radiology (SCAR) even developed a new initiative titled TRIP", Transforming the Radiological Interpretation technology.

In his presentation "Data Explosion I: Current Solutions for a Busy Clinical Practice," Geoffrey D. Rubin, MD, section chief in cardiovascular imaging at Stanford University Medical Center in Palo Alto, Calif, pointed out the basic premise behind 3D visualization.

"CT angiography (CTA) routinely have 375 images to review, for aortic studies we have 450 to 500 images, and for a study of the lower extremity inflow and runoff, we may generate 900 to 1,000 transverse reconstructions," Rubin said. "If we are to optimize our clinical protocols and take full advantage of these CT scanners, we need to change the way that we interpret, transfer, and store CT data. Film is no longer a viable option. Alternative visualization and analysis using volumetric tools, including 3D visualization, must evolve from luxury to necessity."

3D visualization will change how radiologists navigate multislice CT and MRI studies by giving them tools to do multi-planar reformation (MPR), maximum intensity projections (MIP), shaded surface displays (SSD), and volume rendering. Such tools represent a paradigm shift in radiologyand that may be one of the reasons for hesitancy in adding 3D technology. There are other challenges and limitations of the 3D systems as they exist today as well: a steep learning curve, lack of trained personnel, time, and expense.

Lateral and anterior segmented maximum intensity projections of a thoracoabdominal-lower extremity CT angiogram runoff scanned on a 16 multidetector-row CT scanner. Image courtesy of Stanford Radiology 3-D Laboratory.

Still, the value of the dynamic images produced by 3D is clear, and the attitude toward the technology is changing for several reasons, according to Sandy Napel, PhD, associate professor of radiology in the Radiology Sciences Laboratory at Stanford.

"When 3D was first introduced 25 years ago, it was used strictly for research," says Napel, who also has a courtesy appointment in the Department of Electrical Engineering and the Department of Medicine. "Radiologists are very good at what they do. Whenever we would show them the 3D algorithms, they would say it was a lot of work considering that they can often just look at the cross-sections and know if something is cancerous.

"But then radiologists started getting more images to look at, especially with MDCT, and they needed help to look at all those cross-sections," Napel says. "At the same time, computers became more user-friendly and faster and radiologists were no longer intimidated by the technology. Today we are on a part of the learning curve that is changing very rapidly."

Gordon J. Harris, PhD, is director of the 3D Imaging Service at Massachusetts General Hospital's Department of Radiology, at Harvard University in Boston. He also directs the Radiology Computer-Aided Diagnostic Laboratory, which has been in existence for 5 years as a stand-alone, independent clinical service for 3D imaging.

"In the time we have been in existence, we have grown from an average of one examination per day in the first month to 91 examinations per day last month," Harris says. "The 3D images allow us to visualize anatomy and pathology that may have been difficult to interpret in 2D and help to make the assessment much clearer. That can change the clinical management, which results in better care for the patient."

Whole body contrast CT angiogram. Image courtesy of Osman Ratib, MD, PhD, UCLA Department of Radiology.

Reimbursement issues

Just because the technology is available does not mean it is used in every study, however. "There are a lot of things that don't merit 3D," Harris says. "We do more than 100,000 CT scans per year, and about 40,000 MRIs. Out of those, about 5% to 10% of the CTs, 20% of the MRs, and 20% of our ultrasounds are reconstructed and stored as a 3D volumetric data set."

"There are three conditions under which it is appropriate to perform and bill for 3D services within Medicare compliance guidelines," continues Harris. "Under all these conditions, the 3D reconstructions must be performed on an FDA approved software system for billing and reimbursement. The first category is for specific examinations where a referring physician requests 3D reconstruction with the requested scan, such as a surgeon requesting a CT or MR examination with 3D reconstruction for surgical planning purposes. The second condition is if the radiologist reading the examination, after noting positive findings, deems the need for additional views to aid in making a clear diagnosis. In this case with positive findings, the determination of a clinical diagnostic need for additional views by the radiologist does not constitute self-referral. The third way that 3D cases may be performed and billed to Medicare is if the department and/or referring physicians determine that 3D reconstructions should be performed as part of the standard of care for a particular type of examination. In this case, a notice should be sent to all referring physicians to notify them that this will be done and billed, and the 3D reconstructions should be listed as part of the scan protocols and departmental procedures manual. For CTA and MRA, 3D reconstructions are included as part of the examination and 3D must be performed or these examinations are not considered CTA or MRA. However, no additional 3D CPT codes may be charged with CTA or MRA as of 2001.

"This raises the issue of the reimbursements for 3D reconstructions, and the economics of developing a self-supporting clinical 3D Imaging Service," continues Harris. "For all 3D reconstruction other than CTA and MRA, the image post-processing is billed as an add-on to the primary CT, MR, or ultrasound examination under CPT #76375. For Medicare outpatients, depending on whether the 3D equipment and staff are part of a professional organization or part of a hospital, the technical component of the add-on code would be billed under the Ambulatory Payment Classification system for hospital billing (~$100), or the Medicare Physician Fee Schedule (MPFS) under the RVU system for non-hospital billing (~$160). The professional component is minimal (~$9). Prior to 2001, we billed all our 3D exams this way, and developed a self-supporting 3D imaging service. For CTA and MRA, there was a major change in the billing procedures in 2001. Prior to 2001, CTA was billed as a CT without followed by with contrast, plus the separate 3D reconstruction charge. This added $100-$160 in addition to the CT scan reimbursement to pay the costs of 3D workstations, technologist time, and extra images/films. Unfortunately, when the new CTA codes were created, there was no prior single procedure claims data to determine relative costs of CTA vs CT, and the Centers for Medicare & Medicaid Services (CMS) placed CTA in the same APC as CT studies with the same reimbursement, eliminating any additional reimbursement for postprocessing, while requiring that this added work be done for the examination to be considered a CTA. Since then, we have developed a reimbursement sharing model between the hospital, which collects all the CTA and MRA reimbursement, and the 3D imaging service that performs the 3D component. We determined our cost per examination to process these, and the hospital transfers approximately this amount to the 3D lab to cover our costs of providing this service. The fee to the 3D lab has been $115, which represents approximately 25% of our total CTA reimbursement, and about 20% for MRA."

This 3D volume-rendered view of a brain surface from an MRI structural scan shows fMRI hand motor activation areas in red and tumor highlighted in green below the brain surface to enable surgeons to avoid damaging motor and language areas during surgery and decrease exploratory time in the operating room. Image courtesy of Gordon J. Harris, PhD, Massachusetts General Hospital, Boston.

"We have worked, together with the American College of Radiology (ACR), to petition CMS to split CTA into a separate APC from CT, and this was achieved in 2003," notes Harris. "Unfortunately, the 2001 claims data was used to determine the reimbursements, and we found that less than half of all hospitals that submitted CTA claims in 2001 charged more for CTA than CT, so the net differential reimbursement was only $5. If hospital radiology administrators would consult with their chargemaster managers, and revise the CTA charges at their hospital so that CTA charges reflect the CT plus the 3D reconstruction costs, then over the next few years CTA reimbursements will rise to more adequately reflect the added costs of performing CTA vs CT. Otherwise, it is more challenging for new 3D labs to justify their added costs of staff and equipment to the hospital."

Adding value

Not every examination is processed at Stanford's 3D laboratory either, according to laboratory manager Laura Logan.

"We only process those where we can add value, such as studies that require volume rendering," Logan says. "We want to be cost-efficient, and that does not mean adding an extra $763 charge to patients."

Those studies that usually take advantage of 3D postprocessing are CT or MR angiograms, CT IVPs, and pancreas, facial, or musculoskeletal studies. The technologists also review clinical history on any flagged cases to determine if

they are additional studies that would benefit from postprocessing.

"We produce extra images and send them over on our PACS so the radiologist is looking at both the 3D and the source images at the same time," Logan says. "That gives them different views, and they can look at the dataset as a volume or in planes. We also are able to provide lots of quantitation that they can't do on their PACS, like path links, diameter, circumference, and areas of lesions and stenosis. That adds a lot of value."

Technology Issues

At this stage, however, many facilities are offsetting that value against the cost of adding 3D technology. While data management can be performed on CT scanners, Rubin points out that these are expensive pieces of equipment. Dedicated 3D workstationssuch as the ones in place at Stanfordare best equipped to handle the large datasets.

“We use workstations with 2G of RAM, and dual 2 GHz processors with 20 GB of hard drive storage, which are sufficient to handle the large datasets generated by our 16 MDCTs,” Logan says. “Any reduction in these specifications causes productivity to suffer.”

While some vendors currently argue that dedicated hardware represents an edge over the competition, Osman Ratib, MD, PhD, professor and vice-chairman of the Information Systems Department of Radiology at the University of California Los Angeles, disagrees. He has spent the past few years evaluating 3D technology from different vendors, and has not noted a definite advantage.

“I think those that have a core business in building their own hardware will have a difficult time because it is more cost effective to have software-only solutions that run on standard hardware,” Ratib says.

The products currently on the market also have different strengths and weaknesses. “Some are very good at rapid 3D rendering and trimming extraneous objects, while others tend to be better in application-specific ways, such as segmentation tools,” Napel says. “Others have no quantitation tools, so there is no way of measuring stenosis in blood vessels.”

By far, the greater concern about cost has to do with reimbursement. The CPT code for routine 3D reconstruction (CT or MRI) is 76375, but the postprocessing is bundled in with the CT angiogram code. Therefore, reimbursement for large datasets such as runoffs remains the same as for smaller studies, according to Logan.

“There is a clear mismatch between cost in time, resources, manpower, and the infrastructure to support a centralized lab,” Ratib says. “The reimbursement has not followed the technology. On the contrary, they are trying to say it is part of the equipment and not pay extra. We are going in the wrong direction, so the incentive from the financial point of view is hard.

“There is lobbying going on. However, at this point, it is hard to get strong clinical justification, other than an improvement in quality of care,” Ratib says. “Health care economics are not optimal for this to be supported right now. The technology costs a lot of money, and it’s hard to buy a $40,000 workstation when you know it has no financial return investment.”

The Learning Curve

“The obstacle is the time needed to do it right, and justifying staffing costs,” Harris says. Indeed, another measurement of value is in the staff required to manage the new technology. Even when technologists are on hand, they must be educated in 3D’s unique new postprocessing techniques.

“There is a shortage in this field, and that is the biggest problem in creating 3D departments at hospitals. There is no one to staff them,” Logan says. “In addition, the technology takes several months to learn, and it must be learned on the job even if you understand the basic science behind it. The technologists still need to practice and run through a lot of cases, so it takes 6 months before they are at full speed.”

“You really need to have dedicated staff and equipment to adequately provide this type of service,” Harris agrees. “We have five full-time 3D technologists here including our operations manager, and we are looking to hire another. We also have three image analysis specialists, two 3D technologists doing ultrasound, two technical support staffers, a billing and administrative person, and myself.

“The 3D techs do most of the postprocessing, and the CTAs in particular are fairly time-intensive,” Harris says. “It usually takes 45 minutes to an hour to do all the vascular views. For a technologist scanning at a busy center, there is no time to do that.”

“While it would be nice to get more staff, that’s not realistic,” Ratib says. “Instead we have to train more faculty and residents to do the work themselves, and push some of it to the general technologists.”

Some of the work at Stanford and at Massachusetts General is already being done by the radiologists. At Harris's laboratory, vascular radiologists use some 3D workstations to look at different vessels while the technologists process the case to standardize the available views. Radiologists also read the virtual colonoscopy examinations themselves, and some of the neuroradiology fellows do processing for aneurysms overnight.

At Stanford, which has four full-time technologists, the residents, fellows, and radiologists contribute to the off-hour postprocessing needs of the department.

"It's a team effort, and you need both the technologist and radiologist for it to work," Logan says.

Impact and Acceptance of 3D

When it does work, however, those who have been operating a 3D laboratory say the technology has become indispensable.

"The 3D technology is not just about adding on for morphological purposes, it's a diagnostic tool," Ratib says. "By providing this service, we are also getting involved in more clinical decision-making. It improves our relationships with referring physicians, which translates to better referrals, and that puts us on a competing edge with other centers. In fact, we are experiencing a high demand from referring physicians, particularly surgeons, who expect that kind of service as standard."

Ratib also sees a competitive advantage in another use of the 3D visualizationas a communication device.

"We deal with complicated cases and radiologists tend to see things others don't," Ratib says. "Being able to represent that in 3D can help the radiologist become a better communicator with referring physicians, because they now have the tools to explain what they are discussing clinically."

Harris maintains that more facilities are recognizing this marketplace advantage, and implementing 3D because it is less and less practical to practice radiology without those reconstructions.

"By necessity, more and more places are going to either implement 3D solutions or develop potential opportunities for off-site 3D services," Harris says. "They can provide those to hospitals that do not have the infrastructure to develop their own laboratories.

"When 3D started 5 years ago, it was a novelty, and we didn't really need it," Harris continues. "Then, within a short time it went from being a novelty to a necessity. We could not stop delivering that service now. It is an integral part of our practice."

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