From Movies to Medicine

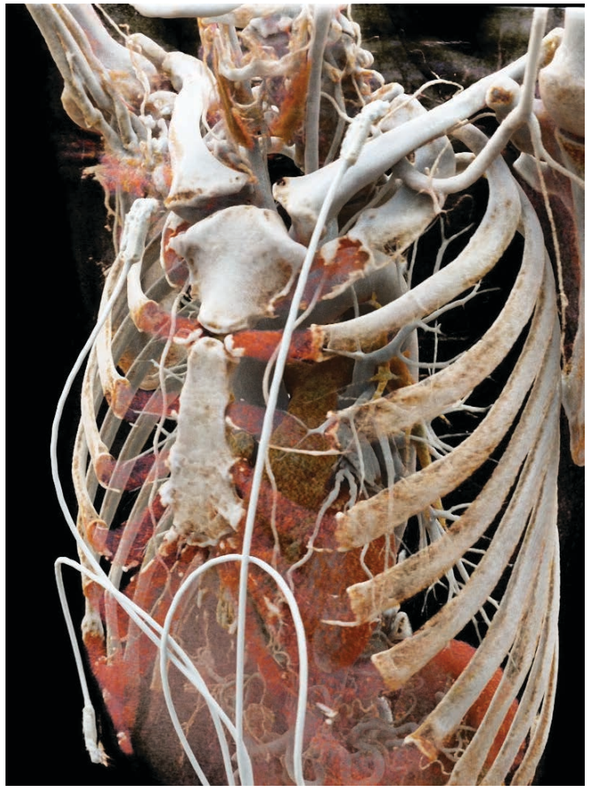
The images are certainly eye-catching, but that's not all. Cinematic rendering – a new type of photorealistic 3D visualization inspired by Hollywood – could transform the way physicians are delivering care.

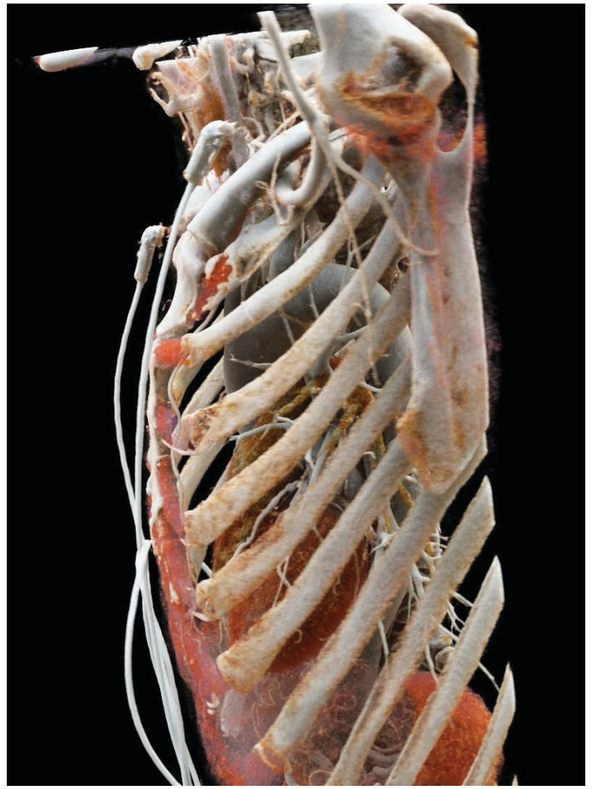
Text: Martin Lindner

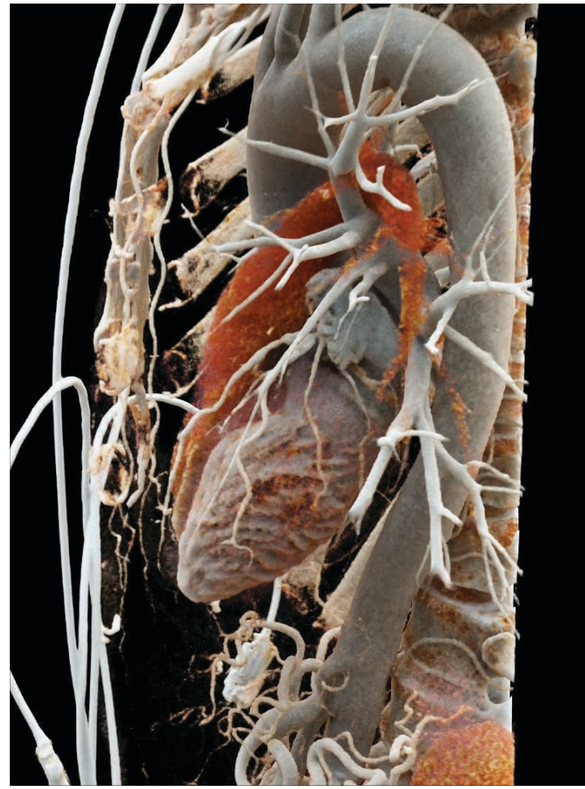
The novel way of reconstructing 3D visualizations from CT and MRI data may help to more efficiently prepare interventions – for example, in cardiac, abdominal, cancer, or trauma surgery patients. The approach could also facilitate communication in interdisciplinary boards and between doctors and patients.

Finding access to the heart

"The more vivid the imaging, the better it is for the surgeon," confirms Arnaud Van Linden of the University Hospital Frankfurt, Germany. Van Linden, a cardiac surgeon, is testing cinematic rendering (CR) for the planning of minimally invasive bypass operations. In these operations, known as MIDCAB (minimally invasive direct coronary artery bypass), an additional vascular conduit is created on the heart via a small incision in the chest wall.







Cinematic rendering provides the potential to plan minimally invasive direct coronary artery bypass (MIDCAB) surgery effectively and safely by determining the optimal intercostal access point, the location of the left internal mammary artery (LIMA) in relation to the sternum, and the left anterior descending (LAD) artery. The photorealistic representation is closer to the real-life surgical view than other imaging representation methods.

"Thanks to CR, we can get a virtual look inside the chest cavity, assess the layout of the vessels, view the heart from the side or from above – and then determine the ideal access point for the operation," says Van Linden. "The images really look just like what you see later in the operation."

This realistic depiction is based on a specific image-synthesis algorithm. CR comes from the film industry (hence the name) and allows, for example, computer-animated figures to appear exceptionally true to life. In medicine, these image reconstructions are most often computed based on contrast-enhanced CT scans, although MRI data would also be suitable.

Principles of cinema applied to medicine

3D renderings are not new in imaging. In the previous standard method, known as volume rendering, an image data set is basically illuminated by a virtual light source, in order to simulate the opacity and color characteristics of the tissue and create the impression of a

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Senior Physician, Clinic for Thoracic and Cardiac Vascular Surgery, University Hospital Frankfurt, Germany

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Visceral Surgeon, Clinic for Surgery,
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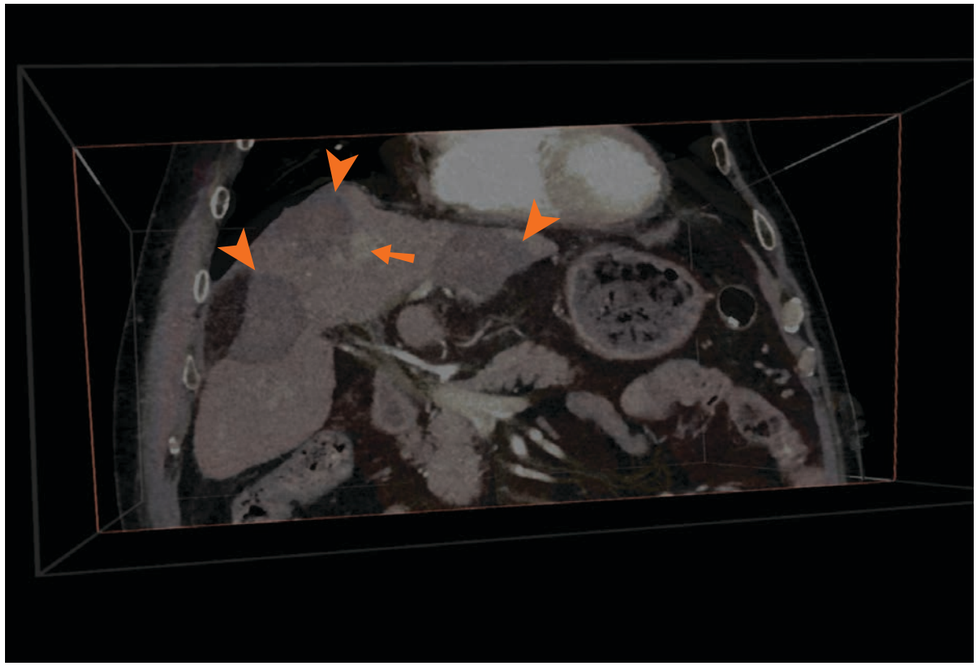
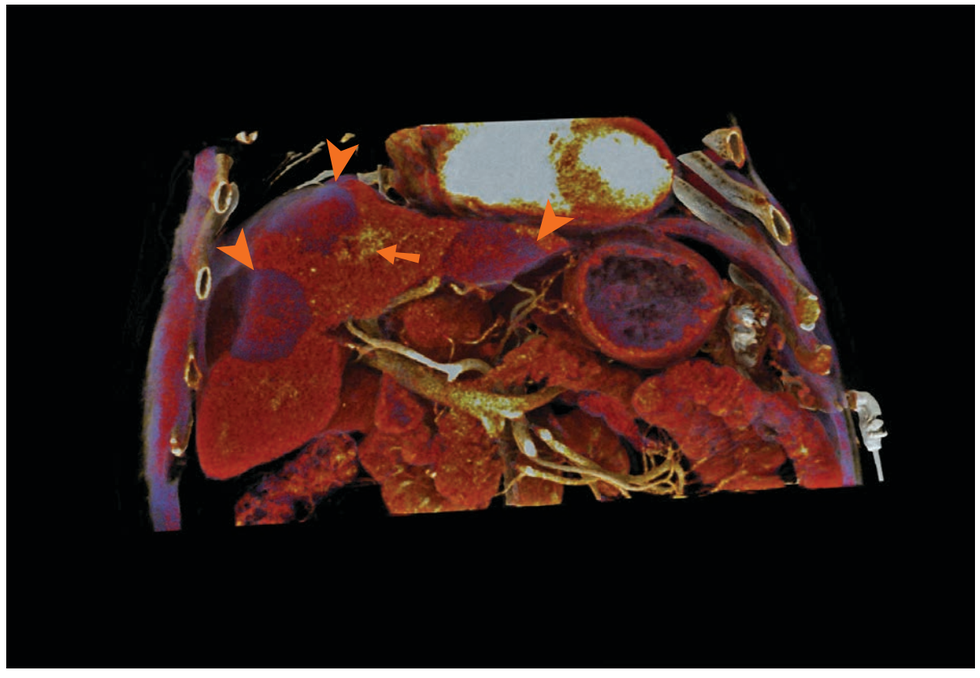
three-dimensional object. CR uses a significantly more complex illumination model, which integrates numerous light- scattering, absorption, and shadowing effects that are important for visual perception in the everyday environment.[1] This makes the images very realistic – and surgical planning easier.

The important thing with MIDCAB is choosing the right surgical path, which can go through the fourth intercostal space or, just as well, the fifth, explains Van Linden. “Sometimes the less optimal access point is chosen, and then you struggle during the operation.” With some patients, only plain X-rays are available for planning; but even with CT scans, heart surgeons occasionally have a hard time getting a precise notion of the anatomical situation. “MIDCAB works without CR – but becomes much more feasible with it,” says Van Linden. Meanwhile, shorter surgeries could also lead to cost savings and faster recovery of the patients.





Recurring hepatocellular carcinoma (arrow) on the edge of a previous ablation procedure (arrowhead).
Left: 2D CT image. Right: CR image for improved therapy planning.

Hybrid procedures by combined teams of cardiac surgeons and interventional cardiologists, or complex pediatric heart surgeries, could presumably also be better planned with the new visualization method, says Van Linden. Last but not least, the fact that CT coronary angiography is increasingly used as a diagnostic alternative to cardiac catheterization (so that CT data are already on hand) could make CR routine in preoperative imaging.[2]

Quick and reliable interpretation of complex anatomy

The same is true for abdominal surgery. “Especially in complex anatomical situations, these visualizations are helpful,” emphasizes Christian Krautz, an abdominal surgeon with the University Hospital Erlangen, Germany.

In a CR evaluation study, 10 experienced senior physicians and 10 residents were to perform anatomical assessments of some difficult cases picked out retrospectively. The physicians were given CT scans, on the one hand, and CR images, on the other, and were asked, for example, to estimate whether a pancreatic tumor was in contact with the superior mesenteric artery or whether there were vascular variants in the liver. This sort of thing can be significant for the intervention strategy.

Using the CR visualizations, the surgeons could in fact answer the questions not only faster, but also more often correctly. The evaluation times for both senior physicians and residents were significantly reduced with cinematic renderings. Meanwhile, the percentage of correct evaluations rose significantly in both groups. Notably, these improvements were more pronounced in the resident group.

“Cinematic rendering takes 3D visualization to the next level.”

Elliot Fishman, MD
Director of Diagnostic Imaging and Body CT, Johns Hopkins Hospital, Baltimore, Maryland, USA

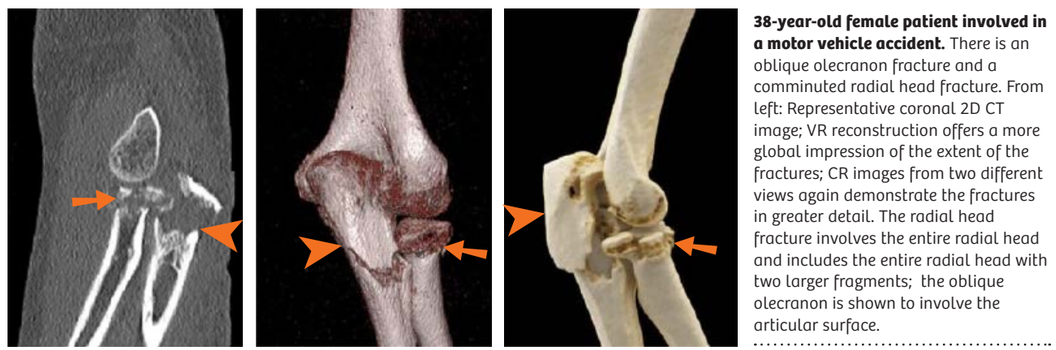
The ability to capture anatomical conditions quickly in 3D could also significantly facilitate communication in interdisciplinary tumor boards, adds Krautz. Moreover, the graphic visualizations may work well in providing information to patients. In a follow-up study, the Erlangen surgeons now envisage using CR prospectively in planning interventions and also to test it as an intraoperative aid to orientation.

Individualizing treatment strategies

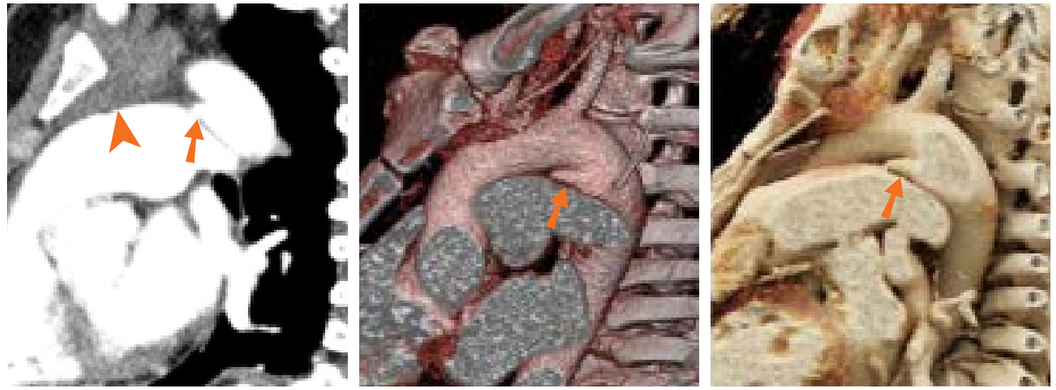
Another example of the use of CR is in trauma surgery, reports Elliot Fishman, 3D imaging specialist at Johns Hopkins Hospital in the United States. After traffic accidents, for example, the extent of injuries is often assessed using contrast-enhanced computer tomography. “This is the standard of care,” says Fishman. Thus, CR reconstructions would usually be possible without additional expense.

Fishman’s team currently uses CR about 50 times a month, and has published a series of case studies by now on things like complicated fractures, gunshot wounds, and stab wounds.[3] According to Fishman, the potential benefit of CR lies primarily in better assessments as to which treatment strategy is best in a given case – for example, whether a fractured pelvis should be operated on immediately or later, and whether an anterior or posterior surgical access is more appropriate. “CR could make surgical decision-making more precise and more confident,” says Fishman.

More-vivid imaging could even help in avoiding unnecessary operations entirely. Fishman and his colleagues described the case of a 23-year-old woman who was in a traffic accident, and



38-year-old female patient involved in a motor vehicle accident. There is an oblique olecranon fracture and a comminuted radial head fracture. From left: Representative coronal 2D CT image; VR reconstruction offers a more global impression of the extent of the fractures; CR images from two different views again demonstrate the fractures in greater detail. The radial head fracture involves the entire radial head and includes the entire radial head with two larger fragments; the oblique olecranon is shown to involve the articular surface.



23-year-old female patient involved in a motor vehicle accident. The patient was the belted front seat driver and the front airbag deployed. From left: Sagittal contrast-enhanced CT image in a plane showing the patient’s ductus diverticulum and the anterior hemomediastinum; volume-rendered visualization of the ductus diverticulum demonstrating the course of the ductus diverticulum as it tracks from the region of the aortic isthmus anteriorly and inferiorly toward the pulmonary arterial vasculature; CR visualization of the ductus diverticulum. The more sophisticated lighting model and improved detail are apparent. The relative relationship of the ductus diverticulum in comparison with surrounding vascular structures is highlighted by the realistic shadowing effects possible with cinematic rendering.

who was initially thought to have suffered a serious injury of the aorta, but it then turned out to be a harmless remnant of a fetal blood vessel (ductus diverticulum). The CT images did show this anatomical condition already, but in 3D rendering it became especially clear.[4]

It will take larger studies to show how great the added benefit of CR will actually be for clinical routine, Fishman admits. “We are still on a sharp learning curve with the approach.” But hardly anyone questions the quality and clarity of the images, he adds. “Cinematic rendering takes 3D visualization to the next level.” ●

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