

# AXIOM Innovations

The Magazine for Interventional Radiology

**14 • Interventional Radiology**  
**New Clinical Indications**  
**for Embolization Procedures**

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**Reducing the Risk**  
**of Non-target Prostatic**  
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## The Gateway to Innovative Clinical Pathways

# AXIOM Innovations

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# The Gateway to Innovative Clinical Pathways

Nuremberg's 310Klinik has installed Germany's first Angio-CT dual-room solution, making space for good ideas.

Text: Andrea Lutz | Photos: Steffen Kirschner

A few hundred meters before you reach the entrance to the 310Klinik in Nuremberg's Nordostpark, you will pass a sign for HighTech Center Nürnberg. Established here in 2002, the 310Klinik exists in the company of innovation-hungry technical service providers, software developers, and materials researchers who have devoted themselves to tackling the big issues of the future. For some time now, the hospital's reputation has extended far beyond the boundaries of the Nuremberg Metropolitan Region. The people behind 310Klinik consistently focus on high-tech medicine, but they also chose the hospital's name to reflect the fact that patient well-being is their top priority: 310 Kelvin corresponds to approximately 37 degrees

Celsius, the figure associated with a healthy body temperature. From the outset, interventional radiologist Michael Moche, MD, was impressed by the unique combination of patient proximity and advanced technology. He therefore left the structures of a renowned university hospital and accepted a position at 310Klinik in Nuremberg. Today, Moche is in charge of the hospital's interventional radiology department. "I like dealing with sophisticated technology," he says. Accordingly, he is working side by side with engineers in the context of several EU-funded projects to develop solutions for interventional procedures. However, he also stresses that "we mustn't be tempted to focus only on images – we must always treat the patient as a whole."

## From a bare industrial building to a hybrid interventional room in record time

CEO Fabian Hubacek is convinced that image-guided interventions are a crucial part in the spectrum of minimally invasive treatments and therapy: “We are sure that many open surgical procedures will be replaced by this technology”. But there are not yet many hospitals in Germany with a dedicated ward staffed by interventional radiologists. Patients treated using interventional techniques are often accommodated on the surgical ward – a perceptual problem that Moche hopes to overcome using his hospital as a model: “Interventional radiology must become a clinical partner for colleagues from other disciplines. In order to do so, we need to specialize even further. We need even more new, committed recruits. Above all, however, we need the opportunity to operate interventional radiology wards and to be integrated into patient preparation and aftercare.” In Nuremberg, Moche can put his ideas about interventional radiology into practice in a dedicated ward that he designed and



gave shape according to his wishes. Moche set up the new department in record time: It took him three months of planning plus three months of construction to go from a bare industrial building to the first intervention in an IR environment whose indoor air classification even permits open surgery and where he was able to realize his vision for a dual-room solution. Hubacek: “The efficiency of the collaboration with Siemens Healthineers was impressive. Short communication paths, maximum technical support, and ongoing consultancy are the keys to success. This allowed the project to be implemented in a short time, whereas it usually takes much longer to complete.” Today, with the exception of neuroradiology, the 310Klinik can cover the entire spectrum of interventional radiology – from acute care to interventional oncology and from peripheral revascularization to embolization for benign diseases in every organ of the body. However, Moche is especially proud of an organizational aspect: “We are an interventional radiology department with its own beds – an independent clinical location that can count on 310Klinik’s entire infrastructure covering surgery, internal medicine, orthopedics, intensive care, and intermediate care.”



Dual-room solution allowing independent usage of CT and angiography.

*“In 70 % of cases, this system will be used independently so the two-room solution can help to increase the utilization rate and enhance return on investment.”*

**Fabian Hubacek**  
CEO, Founder and Shareholder  
310Klinik, Nuremberg, Germany



## Two rooms for greater efficiency and safety

Angiography and computed tomography (CT) are the workhorses of interventional radiology. “We have an especially innovative system with our Angio-CT suite which leverages the strengths of both,” says Moche. He is evidently proud that this is the first system in Germany to be set up as a dual-room solution. Moche believes that dual-room solutions provide key advantages: “Even in procedures where both systems are needed, CT is only applied for a relatively short time during the

## The new nexaris Angio-CT<sup>1</sup>

### Seamless integration

- The common coordinate system unifies CT and angiography. With Instant Fusion<sup>1</sup>, CT volumes – with intra-arterial injection – are instantly overlaid on live fluoro images, allowing fast and easy access to the relevant visuals.
- Quick Switching<sup>2</sup> with smart collision protection: By simply sliding the table between the two modalities, it will be easier than ever to perform CT-guided ablation and angio-guided embolization in one session and on one table.
- Fully connected, the interventionalists will be able to access angiography, CT and ultrasound sources side-by-side on a single, large display in the exam room and via a single Cockpit<sup>2</sup> in the control room. Common Patient Registration<sup>1</sup> allows automated patient data transfer with only one registration at the start.

### Versatile design

- The unique 2-room design of the nexaris Angio-CT allows independent usage of each modality: Different disciplines can work in parallel and potentially raise the utilization rate and return of investment.
- Mounted on rails up to 12 meters in length, the CT gantry slides easily into a dedicated 'garage', while the C-arm swings into the foot-side park position<sup>3</sup>, making space for key personnel by moving the major components out of the way.

### Pioneering potential

- With instant access to optimal imaging technology on one table, a broad range of clinical pathways can be re-shaped, such as bone metastasis, blunt poly trauma, and acute stroke. Advanced functional imaging may make intraprocedural endpoint-determination more precise.

procedure in many cases. In such cases, CT can be used separately in the second room, e.g., for regular diagnostic scans." Accordingly, it quickly became clear that the dual-room option would be the solution of choice for 310Klinik. Hubacek justifies the decision: "In 70 percent of cases, this system will be used independently so the two-room solution can help to increase the utilization rate and enhance return on investment." Moche describes the clear advantage for his workflow: "Although we use the CT scanner for emergencies or to perform complex interventions in combination from the outset, we can slide it into the adjoining room on rails when it's not in use. This gives us more room to move and allows us to work more efficiently, because the CT is then meanwhile available for diagnostics or smaller interventions in the other room." By means of this flexibility, Moche plans to perform regular diagnostics or shorter minimally invasive procedures, for example biopsies, on about eight to ten patients per day in the CT room. On average, these will be joined by five to eight regular angio or two complex interventions with combined percutaneous and endovascular access – for instance, treating an endoleak – where both modalities are needed.

## Treating endoleaks more safely

Endoleak is the most common complication after endovascular stent graft repair of aortic aneurysms (EVAR). "Safe and efficient treatment of type II endoleaks will play a major role in the future," says Moche. Even today, endoleaks are predominantly treated using interventional techniques. Typically, a type II endoleak is punctured using CT guidance, followed by the introduction of a guidewire, and then the patient is moved from the CT unit to the angio suite, which is time-consuming. Moche wants to eliminate the risks known to be associated with this: "When the patient is moved, there is always a risk of dislocating the guidewire. With our new Angio-CT system, we can perform the complete workflow very safely without transferring the patient from CT to the angio suite."



<sup>1</sup> The product/feature is pending 510(k) clearance, and is not yet commercially available in the U.S.

<sup>2</sup> The product/feature is still under development and not commercially available yet. Its future availability cannot be guaranteed.

<sup>3</sup> The product/feature is not commercially available in all countries. Its future availability cannot be guaranteed.

# *“Anyone who aims at exploring new clinical pathways in interventional radiology may consider combined CT and angiography.”*

**Michael Moche, MD, PhD**  
Clinical Director and Head of Diagnostic  
and Interventional Radiology  
310Klinik, Nuremberg, Germany



## **Maintaining a high quality of life for pancreatic cancer patients**

In addition, Moche believes that a new interventional procedure could also benefit from the combined dual-room solution: “Patients with pancreatic cancer often have a poor prognosis – the tumor is rarely resectable and systemic chemotherapy is often ineffective. For these patients, interventional therapies will play an increasingly important role.” One increasingly common procedure is known as Irreversible Electroporation (IRE). It uses ultrashort pulses of high-voltage current to damage tumor cells in a relatively selective manner. “Because no heat is generated in the process, vascular structures are preserved – so the procedure is well suited to treat this aggressive cancer, which is often richly surrounded by vital vessels.” Until now, treatment was often performed via open surgery using sonographic guidance. Moche wants to make the procedure minimally invasive, safer, and more efficient for the clinician to plan. He therefore favors combined treatment, in which he uses fluoroscopy for angiographic visualization of vessels and CT guidance to precisely navigate the probes around the tumor without injuring the vessels: “Intra-arterial injections leverage the strength of both modalities. The superior soft tissue resolution and the better 3D capability are clear advantages over the treatment planning and image guidance under ultrasound.”

## **Training will change dramatically**

Moche is aware that technical progress has revolutionized his discipline in particular over the last few years: “Imaging has made incredible leaps forward. Today, we work with multimodal image guidance, and use PET and CT in combination to visualize functional changes in tumors. In addition, we can merge image data and provide the clinician with additional image information via augmented reality. In the near future, we will further increase the integration of robotic systems, delivering even greater precision and more radiation protection for clinicians.” However, to be able to optimally use all of these capabilities, changes will be needed to train radiologists. “I’m convinced that we’ll need to carry out even more training on simulators in the future in order to make the learning curve steeper. We’ll also need to use simulation software to validate our methods and to plan interventions even more effectively.” Moche is in no doubt that “anyone who aims at exploring new clinical pathways in interventional radiology may consider combined CT and angiography.” However, he adds that those who want to benefit from a system like the Angio-CT suite must also be prepared to explore the capabilities of such a system, and to make consistent use of its advantages. In his opinion, these advantages by no means only apply to complex interventions: “With Angio-CT, we are improving safety in many cases with additional image information, by optimizing the workflow, reducing the time of the intervention, and by completely eliminating the potential risks involved in transferring the patient between the modalities.” ●

*The statements by Siemens’ customers described herein are based on results that were achieved in the customer’s unique setting. Since there is no “typical” hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same results.*

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# Combined Embolization and Ablation in an Angio-CT Interventional Suite

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Courtesy: Bruno C. Odisio, MD, Department of Interventional Radiology,  
The University of Texas MD Anderson Cancer Center, Houston, Texas, USA

## Patient history

A 59-year-old male with metastatic colorectal cancer to spleen

## Diagnosis

The patient was previously diagnosed with metastatic colorectal cancer

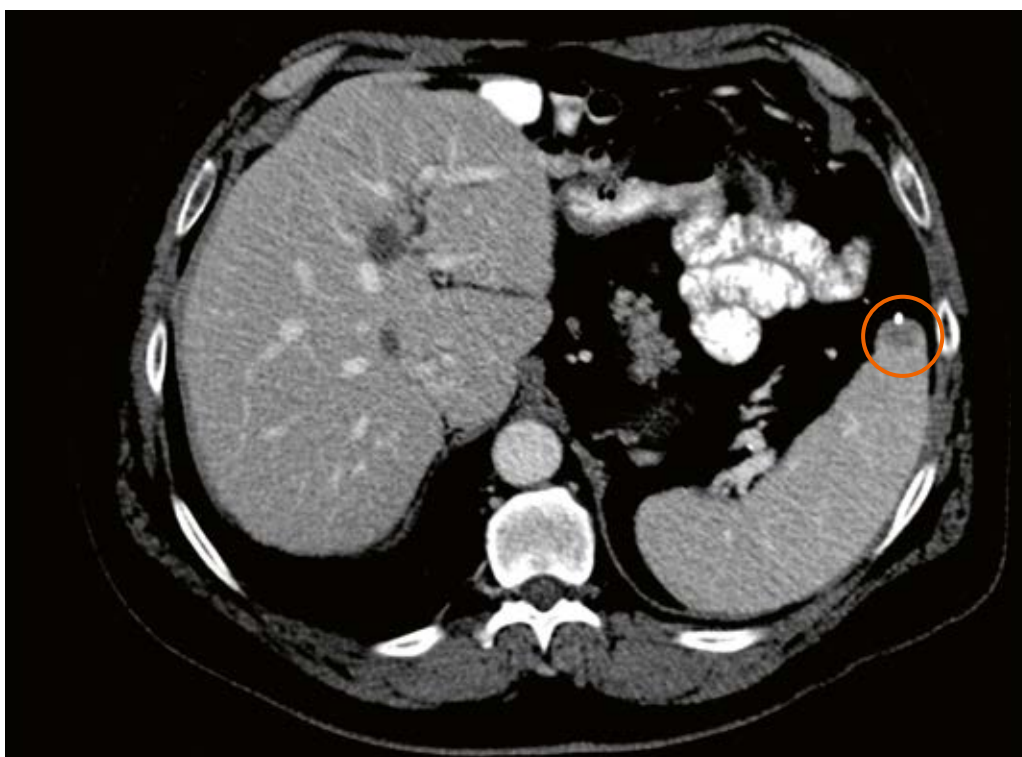
to the liver and successfully treated using CT-guided liver ablation.

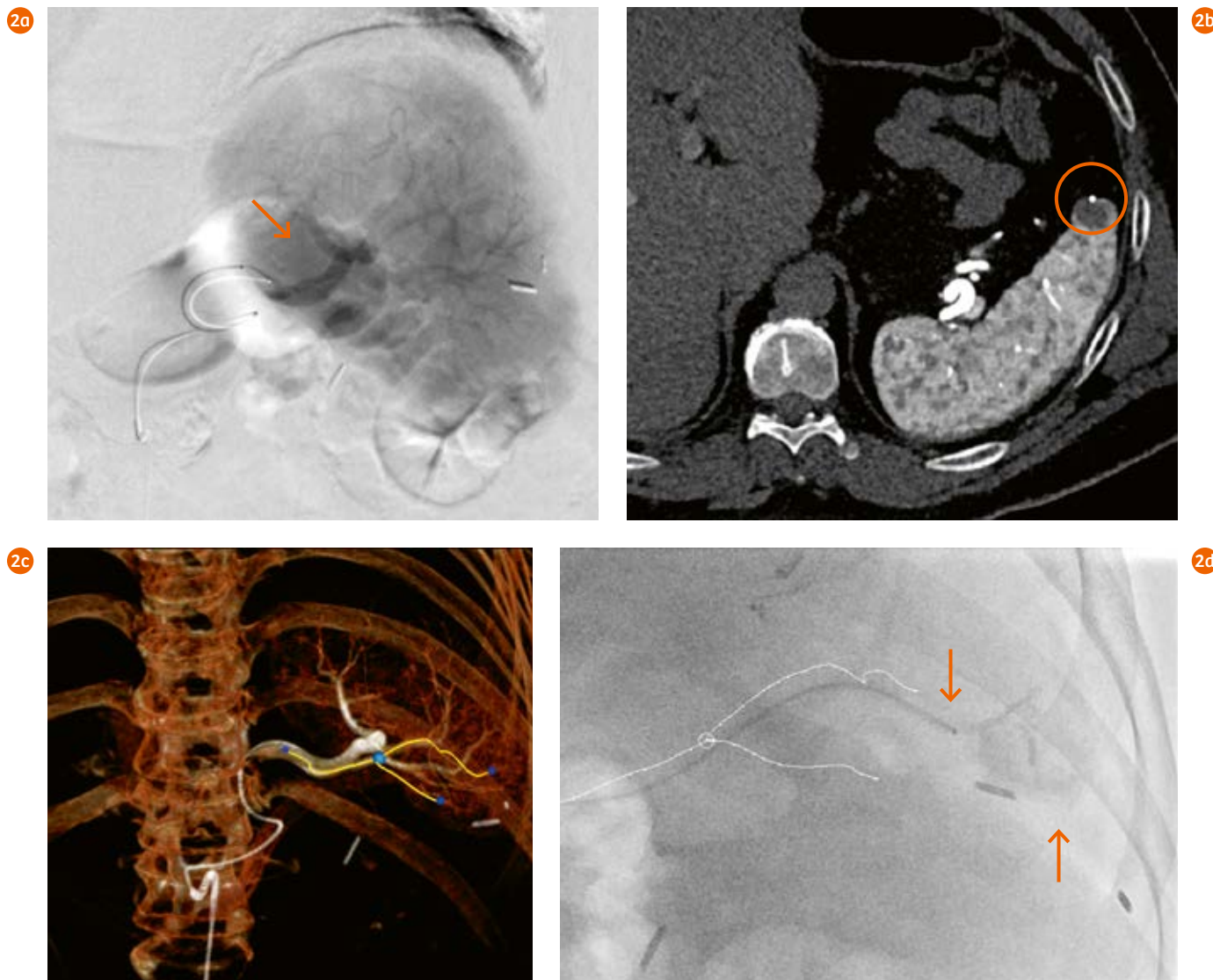
A new metastasis measuring 1.9 cm was found in the superior aspect of the spleen (Fig. 1). This was treated with percutaneous CT-guided micro-wave ablation and with a preablation superselective embolization of the feeder vessels to the tumor in order to reduce the risk of bleeding.

## Treatment

Digital subtraction angiography (DSA) imaging of the splenic vasculature was acquired with femoral access using a 5F catheter into the celiac artery, followed by a 2.8F micro catheter into the splenic artery (Fig. 2a). An intra-arterial CT scan with contrast administration was

**1** Diagnostic CT imaging showing metastasis to spleen. Note the previously treated liver metastasis.





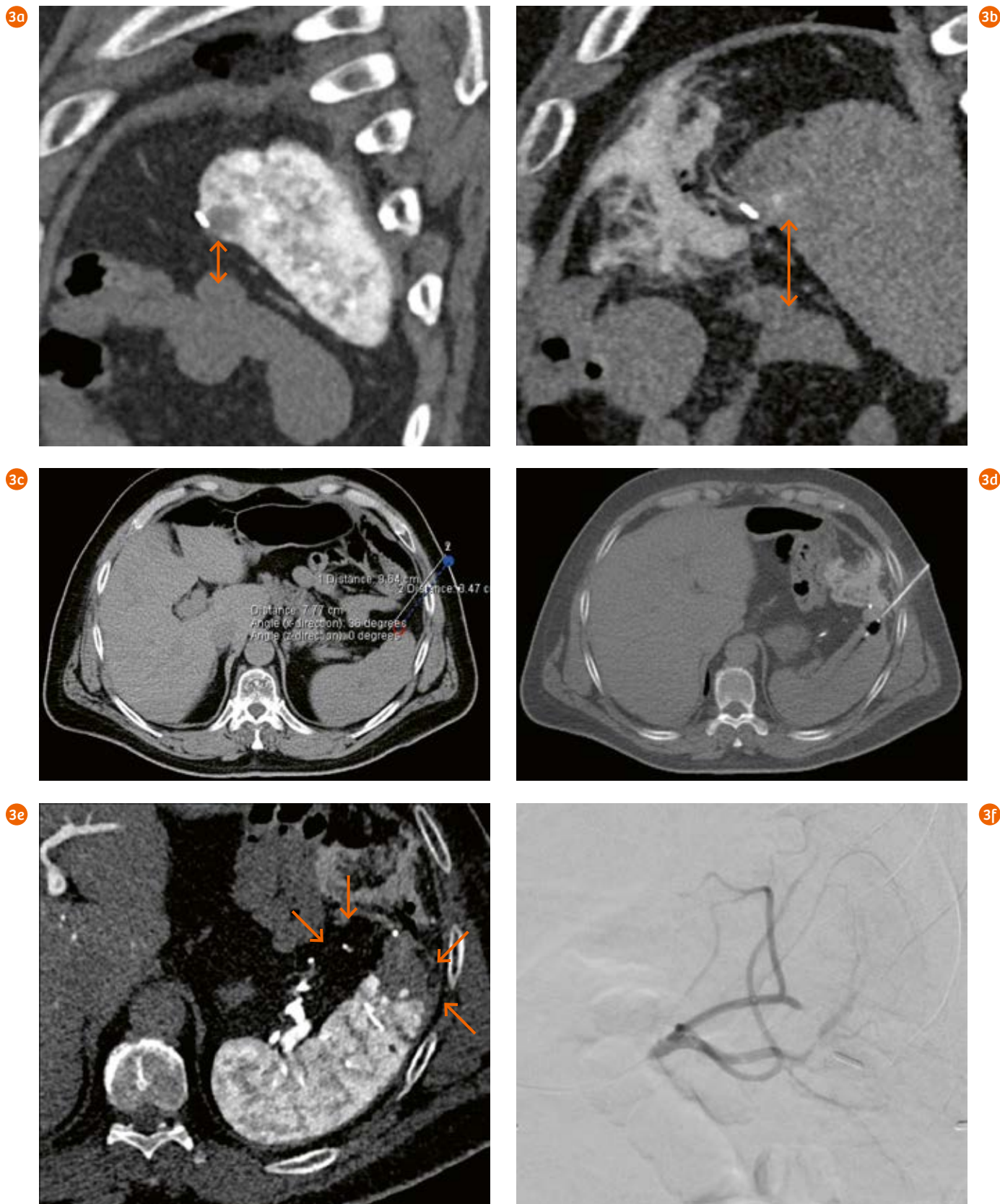
**2** Intraprocedural imaging during preablation embolization. (a) Planar DSA imaging to depict splenic vasculature. (b) Axial slice of intra-arterial CT image showing splenic lesion. (c) Identification of tumor feeder vessels using syngo Embolization Guidance package. (d) Fluoroscopic image of the point of embolization and contrast pooling into the tumor as well as the vessel path overlaid from intra-arterial CT.

acquired from the splenic artery to map out the tumor feeder vessels. The contrast (Omnipaque 350) was administered at a rate of 3 mL/s for a duration of 14 s and a total volume of 42 mL. Multiplanar reformatted (MPR) images of the intra-arterial CT clearly illustrated the hypovascular tumor and the vessels supplying the splenic segment harboring the target tumor (Fig. 2b), which was not obvious on planar DSA images. After delineating the feeder vessels, superselective catheterization of

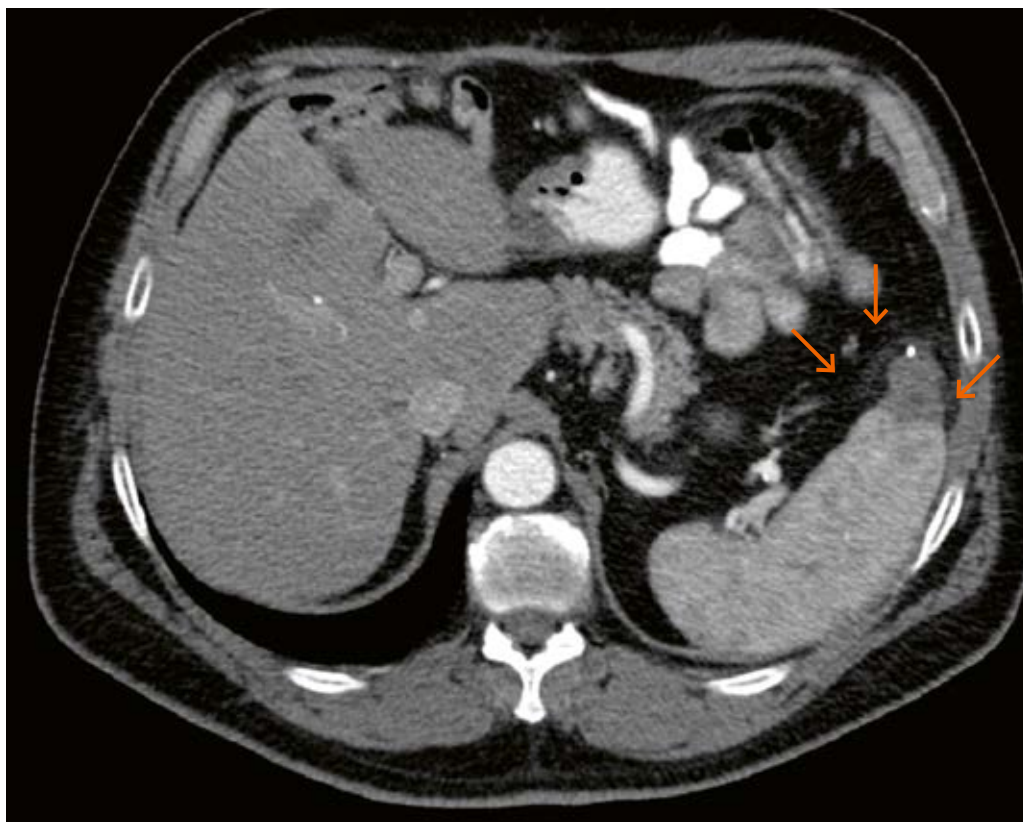
the splenic artery branch supplying the area of interest was performed successfully, and the target feeding branches were embolized to stasis using 900-micron particles (Embozene) in order to reduce potential heat-sink effect (Fig. 2c–2d).

Following the embolization, microwave ablation under CT guidance was performed. In general, the spleen is prone to bleeding during insertion and removal of ablation needles. Therefore, femoral access was

maintained throughout the ablation procedure to mitigate bleeding under angiography where needed. An initial noncontrast CT scan was acquired to plan the ablation needle path. Prior to inserting ablation probes, hydrodissection of perisplenic space with separation of the splenic flexure of the colon was performed successfully under CT guidance using an 18-gauge needle (Fig. 3a–3b). Two microwave antennas were inserted under CT guidance, and microwave ablation was performed



**3** Intraprocedural imaging during microwave ablation. (a)–(b) Cross-sectional slices showing the space between spleen and colon before and after hydrodissection. (c) Axial slice showing the path planning on CT images for placing ablation probes. (d) Axial slice showing the ablation probe. (e) Immediate postablation intra-arterial CT highlighting the ablation margin and (f) Immediate postablation DSA confirming no evidence of bleeding.



**4** Follow-up CT imaging showing successful ablation of the splenic metastasis.

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for 10 minutes at 65 W and a maximum temperature of 134 °C. Immediately after the removal of the ablation probes, the patient became tachycardic and hypotensive. A DSA was therefore acquired to rule out any bleeding caused by vasovagal reaction. Intra-arterial contrast-enhanced CT, also performed toward the end of the ablation procedure, confirmed the ablation margins and indicated no bleeding from the ablation (Fig. 3).

## Follow-up imaging

Ablation and preablation embolization were performed successfully in the same setting with both angiographic and CT imaging. Follow-up CT imaging after 2 months showed primary efficacy of the combined embolization-ablation procedure with no residual disease (Fig. 4). Patient has remained disease-free for 11 months.

## Comments

This combined embolization and ablation procedure was performed in an Angio-CT suite equipped with a CT scanner (SOMATOM Definition Edge with 128 slices) and a flat-panel C-arm angiography system (Artis Q, ceiling-mounted) with a common patient table, thus facilitating the advantages of imaging and image guidance using the two modalities. Since embolization is an intra-arterial therapy, it is performed in an angiography suite, while ablation, a percutaneous procedure, is traditionally performed using CT or ultrasound imaging. However, the combination of a CT scanner and angiography system allowed us to perform these two procedures in the same setting and with successful interplay of the technical and imaging information between the two procedures. For example, intra-arterial CT imaging was used to accurately identify the vessels feeding the splenic segment harboring the tumor

during the embolization procedure under angiography imaging. Similarly, immediate postablation assessment of potential bleeding and ablation margins was performed, respectively, using DSA and CT imaging acquired with intra-arterial access. As a safety measure, CT-guided hydrodissection was performed to avoid ablation of critical structures, and femoral access was maintained for angiographic detection and embolization of possible bleeding. In summary, combining CT and angiography systems not only has the potential to enable these complex combined techniques, but also to bring the existing interventional therapies to a new level. ●

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# New Clinical Indications for Embolization Procedures

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Transarterial embolization procedures are a recognized therapy option for hepatocellular carcinoma (HCC). University Hospital Frankfurt is increasingly combining these procedures with new angiographic technology to also treat benign prostatic hyperplasia and uterine fibroids.

Text: Hildegard Kaulen, PhD | Photos: Tim Wegner

**Y**ou can tell that Thomas Vogl, MD, is a successful interventional radiologist just by looking at his desk, on which dozens of little glass ornaments are lined up, given to him partly by grateful patients. For the last 18 years, Vogl has been director of the Institute for Diagnostic and Interventional Radiology at University Hospital Frankfurt, where he has set up one of the biggest transarterial chemoembolization (TACE) centers in Germany. With its reputation, the center attracts worldwide attention among cancer patients, who come to Frankfurt to receive interventional treatment. Vogl has performed TACE for hepatocellular carcinoma over 5,000 times, and every year he and his internist and surgeon colleagues see around 250 new patients. Vogl treats half of these new patients with chemoembolization. In this procedure, chemotherapeutic drugs and embolic agents are injected directly into the tumor via

the hepatic artery. Besides this, Vogl also performs a whole range of vascular procedures, which regularly accrue in a large German university hospital and for which he needs good image quality, low dose, and short intervention times. For a while now, he has also been exploring new indications for embolization procedures using ARTIS pheno, a novel, robotic angiographic technology.

Vogl likes the new system because the image quality he demands for his procedures can now be obtained at considerably lower doses. Furthermore the system gives him the opportunity to choose: In critical situations he is able to invest in superior image quality, still without exceeding the dose levels he was used to in the past. "We're now increasingly addressing indications that we couldn't do previously, because we weren't able to resolve certain anatomic structures or inflict such high doses on



the patient,” explains Vogl. He uses the improved image quality in the embolization of the prostate in cases of benign prostatic hyperplasia. The lower dose helps when it comes to embolizing uterine fibroids. “The reduced dose is a powerful argument for young women who still want to have children.”

## Shorter intervention time for greater safety

For Vogl, short intervention times are also important, because they affect the safety of the procedure. “Thanks to the good image quality, we can now reach the tumor more quickly because we can navigate our way faster through complex organs like the prostate when doing interventions.

This means there’s less risk of complications, mainly due to reduced procedure time,” explains Vogl. “I would gain nothing if I were to use equipment with a low dose and low resolution but took twenty minutes instead of ten,” he continues. Using ARTIS pheno, Vogl can embolize both the liver and the prostate faster than before.

To protect himself and his team from unnecessary radiation, Vogl recently requested the X-ray dose required for all organ programs in the new system to be further reduced. Now Vogl only resorts to the previous programs with the original dose if the image quality is not sufficient. Hence, for each intervention he decides what matters more: Better image quality or lower dose. “I always start out without the extra dose,” he says. “I’ll only use the button to switch to a higher dose if I notice that it’s taking longer to probe the vessels or if I encounter difficulties.”

A member of Vogl's team is currently evaluating all the examination reports to identify the clinical situations in which he switches to the higher dose. Vogl and his team hope this will produce interesting insights into precisely what is required in procedures of this sort.

Vogl also sees it as a great advantage that he can display earlier CT and MRI images on one of the two monitors and view them together with the real-time image. This enables him to use information from preoperative examinations, such as the excellent soft tissue contrast displayed in MRI images. "This extra visual information helps me set the C-arm to always give me the best possible view of the vessels. Then I can see very precisely where and using which angulation I can get the best view of the vascular junctions," says Vogl.

## Perfusion and prognosis

Vogl begins the TACE for hepatocellular carcinoma with a *syngo* DynaCT run. He does two 3-second scans with a rotation of 200° each. A native scan, known as a mask run, is followed by a contrast run. Vogl then uses the *syngo* DynaPBV Body application to evaluate the volume of blood in the parenchyma of the tumors. These DynaCT data provide information about the localization and blood volume of the liver tumors, and can give a prognosis on

response to treatment. "On the basis of our experience and a large number of examinations, we know that well-perfused tumors respond better to chemotherapeutic drugs than those with a poor supply of blood," explains Vogl. "The rule of thumb in oncology says that if it grows quickly, it can also go away quickly. For this reason it is easier to treat a fast-growing tumor than a slow-growing one." He adds that no matter how much cytostatic agent you pour on resting cells, nothing will happen. On the basis of the derived perfusion, Vogl also decides what kind of cytostatics he is going to use and in what dose. "Prognosis is difficult for blood volume values of less than 80 mL. In these cases you have to chemoembolize very aggressively," says Vogl. "You can expect good results with blood volume values between 80 and 120 mL. For values of more than 120 mL, chemoembolization is going to work extremely well."

So how successful is TACE in cases of hepatocellular carcinoma? "That depends on how well we select patients. If perfusion imaging shows poor blood flow, we'll opt for a different therapy rather than repeating the chemoembolization," continues Vogl. For every fifth HCC patient treated with TACE, the intervention is the bridge to a curative therapy. "If, for example, we have a patient with six to eight lesions in their liver, the surgeon can remove a hepatic lobe, and we'll do the rest with chemoembolization."



Assessment of the full vessel anatomy, automatic feeder detection, and individualized patient selection allow for targeted embolization procedures.



*“I now need a third less time to embolize the liver or prostate.”*

**Professor Thomas Vogl, MD**  
Director of the Institute for Diagnostic and  
Interventional Radiology at University Hospital  
Frankfurt, Germany

## Application to probe tumor feeders

The new system was also equipped with a new application called *syngo* Embolization Guidance with automatic feeder detection for liver lesions. The application uses color coding to show the anatomy of the arteries. Vogl mainly uses the software for probing the prostate. “*syngo* Embolization Guidance is so exciting with this organ because I need scans at extreme angles and have to see very clearly where the arteries are going,” he explains. When embolizing the liver, Vogl relies on the experience he has gathered in the course of more than 5,000 procedures. “My staff also uses *syngo* Embolization Guidance for the liver,” he explains. “The application is a great help for anyone with less experience.” The system’s low acquisition dose allows Vogl to end the TACE procedure with another DynaCT run: “From this scan, I can see immediately how the embolic agent has dispersed, whether it has reached the right place, whether there’s bleeding, and whether anything has been displaced.” Vogl also likes the new hygiene approach of the imaging system. The growing number of hospital infections and multiresistant pathogens pose a major threat, particularly for patients with serious primary diseases. “The new system helps us keep the risk of infection in the angio suite as low as possible,” says Vogl. He knows that he is dealing with a vulnerable group of people. ●

**Dr. Hildegard Kaulen** is a molecular biologist. After sojourns at Rockefeller University (New York) and Harvard Medical School, since the mid-1990s she has worked as a freelance scientific journalist writing for prestigious daily newspapers and science magazines.



Thomas Vogl, MD, and his team are working with the new robotic angiography system ARTIS pheno.

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# Comprehensive Tumor Assessment as the Foundation of Optimal Therapy Planning

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Courtesy: Masao Hamuro, MD, Yoshinori Takao, and Takao Ichida, Osaka City University Hospital, Japan



Yoshinori Takao, RT (left), Masao Hamuro, MD (center), and Takao Ichida, RT (right) in front of their Artis zee biplane system.

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## Patient history

A 70-year-old male patient with hepatitis C virus positive cirrhosis presented with hepatocellular carcinoma (HCC).<sup>1</sup> The patient had been diagnosed with chronic hepatitis C and treated at another hospital for several years. When he was diagnosed with multiple HCC two years ago, he underwent TACE treatment at the same hospital with regular follow-ups. Recently, multiple recurrent HCC was observed on dynamic contrast-enhanced CT and EOB-MRI (ethoxybenzyl-enhanced MRI) during follow-up at the hospital. Finally, the patient was introduced to our institute for further treatment.

<sup>1</sup> The multiphase acquisition described here is realized with the commercially available options syngo DynaPBV Body and syngo DynaCT.

1



- 1 Tumor stain was observed in the posterior segment of the right lobe of the liver (early phase).

2

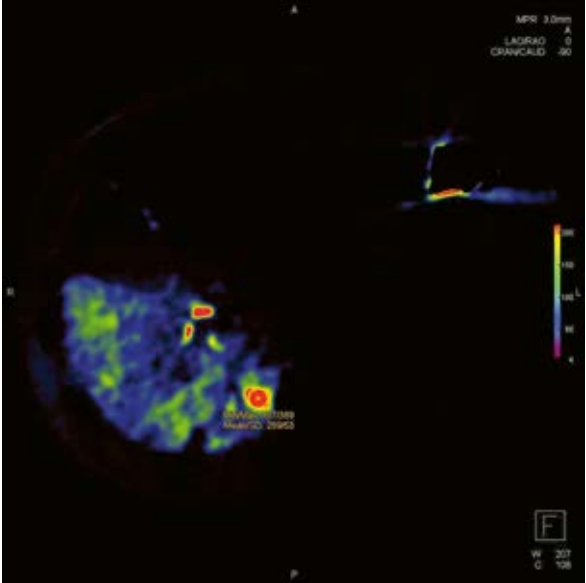
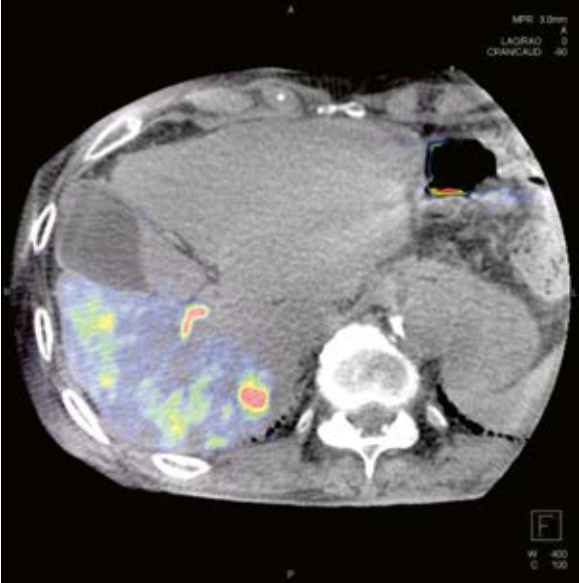


- 2 Corona enhancement was observed in the posterior segment of the right lobe of the liver (Late phase). It was definitively diagnosed as HCC.

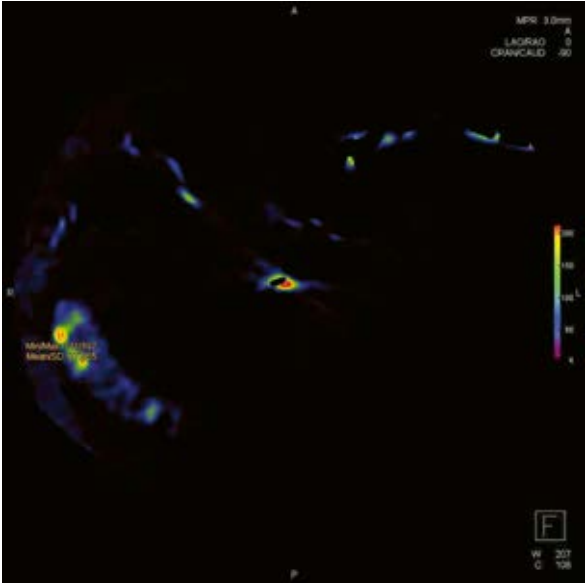
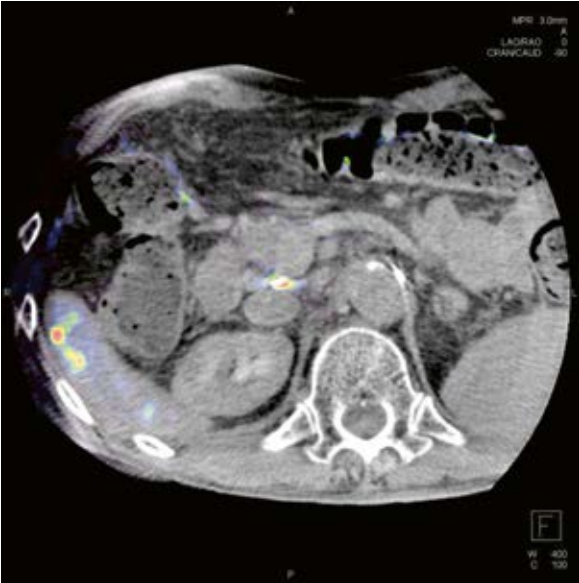
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- 3 Hepatic vasculature is clearly visualized with MIP representation from the same acquisition as in image 1.
- 4 The PBV value of the HCC is relatively high, so TACE treatment is expected to be very effective in this patient.
- 5 A small tumor was clearly visible in segment 6 of the liver. The PBV images are expected to help detect these kinds of small lesions.

## Diagnosis

The patient has a replaced right hepatic artery that branches off from the superior mesenteric artery. Two separate CTHA acquisitions (*syngo* DynaCT during hepatic arteriography) were performed with contrast injection into the right and left hepatic arteries. The modified combined *syngo* DynaPBV / *syngo* DynaCT protocol was applied to the right hepatic artery.

The patient was diagnosed with multiple recurrent HCC based on the detection of various regions with perfusion defect in an additional *syngo* DynaCT acquisition during arterial portography (CTAP). CTAP is considered to be the most sensitive technique for detecting intrahepatic tumors.

Early enhancement and corona enhancement were observed in the same regions in the CTHA images from the modified *syngo* DynaPBV / *syngo* DynaCT acquisition. Correlation between CTAP and CTHA confirmed the differential diagnosis of HCC.

The *syngo* DynaPBV image was useful in detecting a very small lesion in segment 6. The lesion was clearly visible on in the PBV map.

## Treatment

A microcatheter was selectively inserted into the feeding arteries through the right and left hepatic arteries. Lipiodol emulsion and gelatin sponge were then injected for TACE treatment.

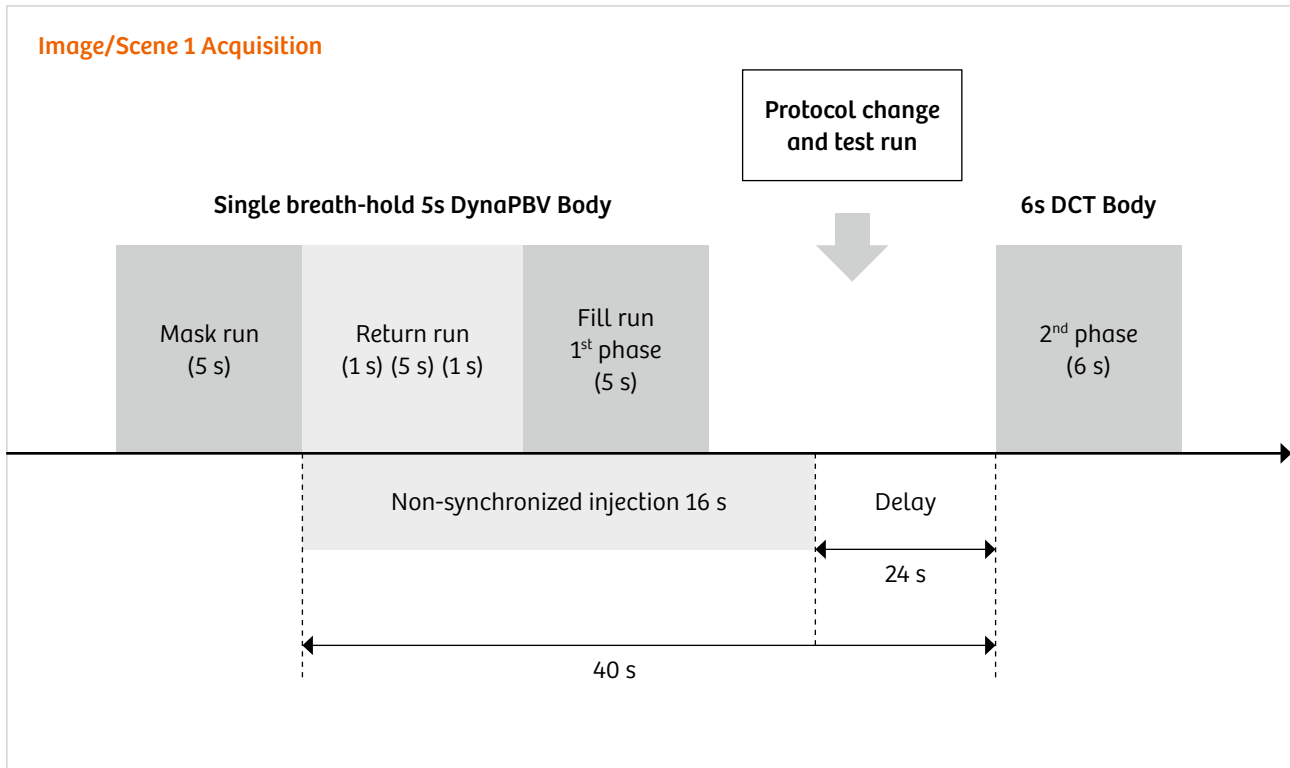
## Comments

A standard workflow in our institute used to involve performing dual-phase *syngo* DynaCT during hepatic arteriography just before administering chemoembolic material in TACE procedures in HCC patients. In addition, *syngo* DynaPBV Body imaging for assessing parenchymal blood volume was independently performed as an optional acquisition after CTHA.

In order to improve our approach and make it more efficient, we intend to introduce a manual 3-phase procedure to acquire both the parenchymal blood volume and CTHA images in one series of acquisitions with a single shot of contrast medium (modified *syngo* DynaPBV / *syngo* DynaCT).

**Acquisition protocol**

	X-ray delay	PBV run: Manual CM injection started when C-arm finished mask run; 7 s acquisition delay while C-arm returned for fill run  Corona phase: 24 s delay after end of injection
<b>Injection protocol</b>	Contrast type & concentration	CM 300 mg/mL
	Dilution	50 %
	Volume (mL)	32 mL
	Power injector used (yes/no)	yes
	Injection rate (mL/s)	2 mL/s
	Duration of injection (s)	16 s
	Catheter position	Right hepatic artery
<b>Reconstruction (syngo DynaPBV)</b>	VOI size	Full
	Slice matrix	512 x 512
	Kernel type	HU
	Image characteristics	smooth
	Reconstruction mode	Dual (Sub and Mask)
	Viewing preset	PBV body
<b>Secondary reconstruction (DynaPBV fill run), early arterial (CTHA) phase</b>	VOI size	Full
	Slice matrix	512 x 512
	Kernel type	HU
	Image characteristics	normal
	Reconstruction mode	Nat Fill
	Viewing preset	DynaCT Body
<b>Reconstruction (syngo DynaCT), late arterial (corona) phase</b>	VOI size	Full
	Slice matrix	512 x 512
	Kernel type	HU
	Image characteristics	normal
	Reconstruction mode	Nat Fill
	Viewing preset	DynaCT Body



The simultaneous scan with *syngo* DynaPBV and dual-phase *syngo* DynaCT (modified *syngo* DynaPBV / *syngo* DynaCT) reduces both radiation dose and contrast medium with the benefit of acquiring *syngo* DynaPBV images in addition to dual-phase *syngo* DynaCT images. This is especially beneficial for patients who require multiple CTHA acquisitions throughout their TACE treatment.

## Tips and tricks

The 6-second *syngo* DynaCT run that follows the *syngo* DynaPBV Body acquisition can provide information on the characteristics of each tumor.

In general, a contrast injection time of 12 seconds (7 seconds acquisition delay + 5 seconds during fill run) is recommended for the *syngo* DynaPBV acquisition.

However, we extended it to 16 seconds. By extending the contrast injection time by 4 seconds beyond the end of the fill run of the *syngo* DynaPBV Body acquisition, we can achieve better corona enhancement in the subsequent *syngo* DynaCT showing a late arterial (corona) phase. This still gives us enough time to manually change the acquisition protocol of the Artis imaging system. ●

## Reference

Parenchymal blood volume (PBV) imaging is useful for developing a treatment strategy or predicting tumor response after transarterial chemoembolization (TACE) in hepatocellular carcinoma (HCC) patients. (Invest Radiol. 2016 Feb; 51(2):121-6, Eur Radiol. 2016 Mar; 26(3):755-63)

*The outcomes by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same results.*

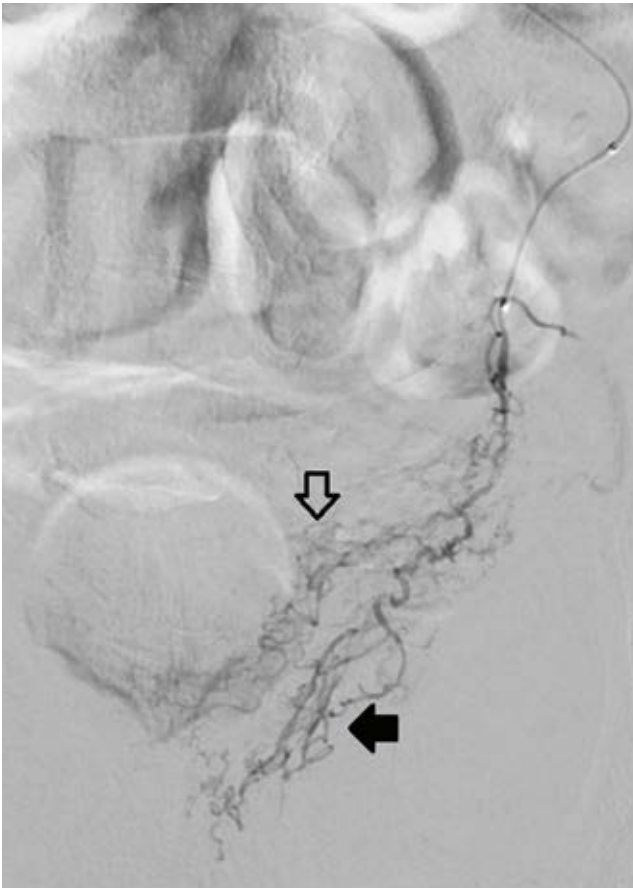
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# Reducing the Risk of Non-target Prostatic Artery Embolization

---

Courtesy: Andre Uflacker, MD, and Ziv J. Haskal, MD, Department of Radiology and Medical Imaging, Division of Vascular and Interventional Radiology, University of Virginia, Charlottesville, VA, USA

1



## Patient history

The patient was a 72-year-old male with lower urinary tract symptoms caused by benign prostatic hyperplasia. Symptoms consisted of straining, hesitancy, and weak stream, with a frequency of almost every hour during the day, and 8 episodes of nocturia. Prostatomegaly was present with a total volume of 53 mL. Prior to treatment, the patient's International Prostate Symptom Score (IPSS) was

22, with a peak urine flow rate of 4 mL/s. One year after treatment, his IPSS was 4, and peak flow rate was 6 mL/s. Nocturia improved to 3 episodes per night, down from 8. Straining, hesitancy, and weak stream were all improved to the patient's satisfaction.

## Diagnosis

Benign prostatic hypertrophy with lower urinary tract symptoms.

## Treatment

Particle embolization was performed using 100- $\mu$ m Embozene via right common femoral artery access. Angiograms were initially performed with 35 degrees of obliquity ipsilateral to the hemipelvis being treated, with 10 degrees of caudal tilt. Subsequent angiograms were performed with projections that were best suited to the prostatic artery after identification.

2



- 1** Left: Digital subtraction angiogram (DSA) in the left anterior oblique projection of the left prostatovesical trunk showing the prostatic branches (solid black arrow) and the inferior vesical branches (hollow arrow).

Right: syngo DynaCT injection with the catheter in the same position at 0.2 mL/s for 2 mL confirms bladder wall enhancement (hollow arrow) and prostatic parenchymal enhancement (solid white arrow).

- 2** syngo DynaCT with power injection after advancing the microcatheter into the left prostatic artery distal to the vesical branches at 0.4 mL/s for 9 mL: No bladder wall enhancement (solid white arrow), enhancement of the left hemiprostate parenchyma (hollow arrow), and visualization of the periprostatic venous plexus (solid black arrow).

## Comments

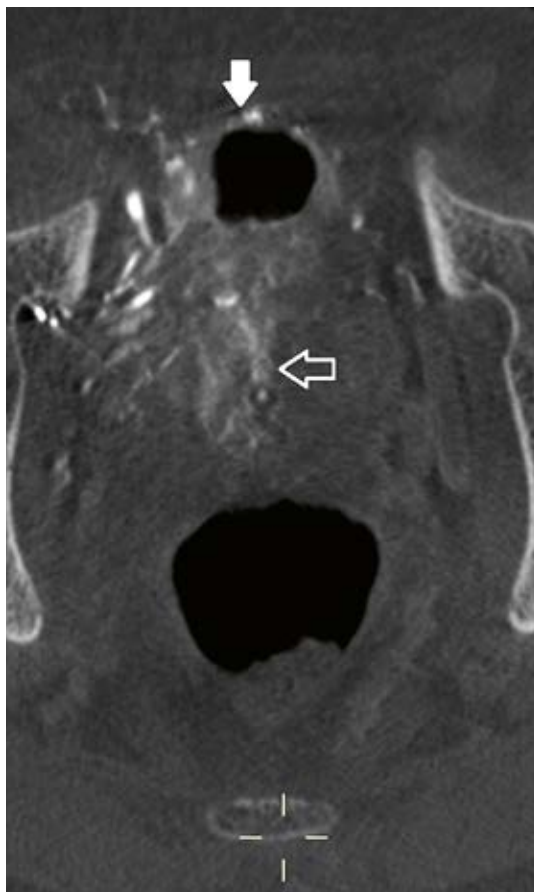
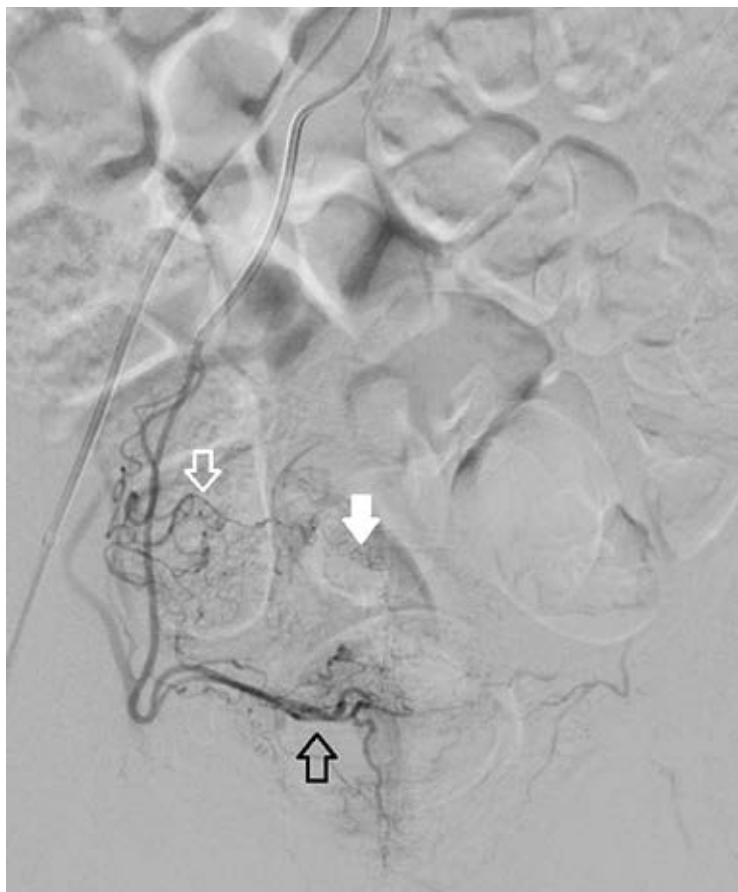
Five DynaCT runs were performed with injections ranging from 0.2 mL/s to 0.5 mL/s, and volumes ranging from 2 mL to 9 mL, each with 10–14 seconds X-ray delay. Injection parameters were specified at the operator's discretion to facilitate filling of the vascular bed distal to the catheter tip but avoiding reflux into vessels proximal to the tip. The first *syngo* DynaCT was performed to visualize the left prostatic artery, with the catheter in the left iliac artery. The second DynaCT run was

performed after advancing the microcatheter into the left prostatovesical trunk, which showed enhancement of the bladder wall and seminal vesicles. Advancing the microcatheter more distally into the prostatic artery showed prostatic parenchymal enhancement and no enhancement of the bladder. *syngo* DynaCT in the right prostatovesical trunk also showed bladder enhancement, which resolved after advancing the microcatheter into the distal right prostatic artery. The five DynaCT runs that were performed during the procedure had an average DAP of 34,937 mGycm<sup>2</sup>.

## Protocol

The following standards regarding cone beam CT acquisition and injection protocols – depending on catheter position and vascular bed – have been established at the University of Virginia in the meantime:

3



Acquisition protocol	5s DCT Body CARE
Injection protocol	
Dilution	No
Injection volume	2–4 mL
Injection rate	0.2 mL/s
Duration of injection	10–20 s
X-ray delay	10–14 s

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- 3** Left: DSA of the right prostatovesical trunk through a 4F catheter showing numerous vesiculodeferential branches (hollow white arrow), bladder branches (solid white arrow), and prostatic branches (hollow black arrow).  
Right: syngo DynaCT with the catheter in this position at 0.5 mL/s for 9 mL showing enhancement of the bladder wall (solid white arrow) and prostatic parenchyma (hollow arrow).
- 4** Left: DSA with the catheter advanced as distally as possible into the right prostatic artery.  
Right: Coronal projection from MPR of the syngo DynaCT in this position at 0.4 mL/s for 7 mL showing no enhancement of the bladder wall (hollow arrow) and prostatic parenchymal enhancement (solid white arrow).



# Endovascular Revascularization for Atherosclerotic Pudendal Artery Obstructions

---

Courtesy: Nicolas Diehm, MD, Vascular Institute Central Switzerland, Aarau, Switzerland



## Patient history

A 56-year-old male presented for vascular workup of erectile dysfunction (ED). He complained of a massive reduction in his penile rigidity leading to an inability to have sexual intercourse for the last 2 years despite the use of phosphodiesterase-5 inhibitors (Viagra). A workup with an urologist delivered no specific pathological findings and his testosterone levels were normal. His cardiovascular risk factors included cigarette smoking (40 pack years).

## Diagnosis

Arterial oscillometry, ankle brachial indices, and duplex sonography of the aorto-iliac arteries revealed moderate arterial calcifications of lower limb arteries in both legs. Moreover, duplex sonography of the cavernosal artery subsequent to intracavernous application of 10 µg of Caverject® (Alprostadil) revealed pathologically slow arterial flow velocities suggesting hemodynamically relevant arterial obstructions of erection-related pelvic arteries.

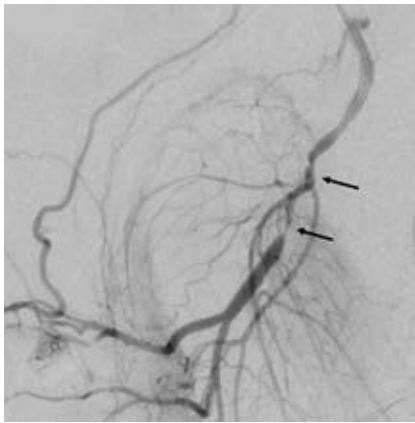
Subsequently, CT angiography confirmed the presence of a left-sided pudendal artery obstruction.

## Treatment

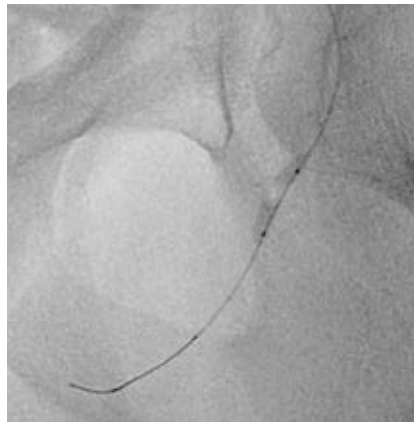
The patient was approved for angioplasty. After retrograde puncture of the right common femoral artery, the left hypogastric artery was engaged using an up-and-over approach. Selective and superselective angiograms of the pudendal arteries were performed subsequent to local intra-arterial administration

*“The impressive image quality enables a procedure which can be used as a promising form of therapy for patients who are not responding to a pharmacological therapy.”*

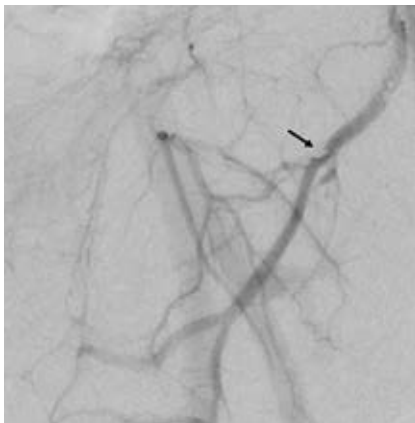
Nicolas Diehm, MD  
Vascular Institute Central Switzerland,  
Aarau, Switzerland



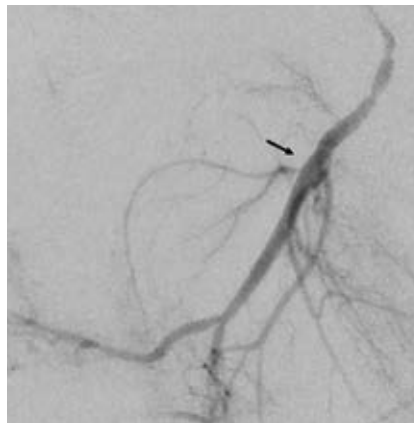
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- 1 Selective intra-arterial angiogram (acquired with Artis Q angiography system) of the left pudendal internal artery showing a tandem lesion distally (arrows).
- 2 Plain balloon angioplasty with a 3/20 mm low-profile balloon.
- 3 Post-angioplasty DSA showed an acute recoil with a residual stenosis that was considered clinically relevant (arrow).
- 4 A 3/22 mm coronary drug-eluting stent (Coroflex® ISAR, B. BRAUN, Germany) was implanted into the lesion (arrow). Favorable angiographic result without residual obstruction.

of nitroglycerine, thereby confirming the presence of a tandem stenosis in the left distal pudendal internal artery (Fig. 1). Quantitative vessel analysis enabled measurement of arterial dimensions and the choice of catheter material. The lesion was dilated with a 3/20 mm balloon following navigation into the artery with a 0.014 inch (0.36 mm) guidewire (Fig. 2). Subsequently, a relevant arterial recoil was noted (Fig. 3) necessitating the implantation of a coronary drug-eluting stent (Fig. 4). After stent deployment, wide reconstitution of the treated artery was noted.

At three months, the patient's erectile function returned to normal without further need of phosphodiesterase-5 inhibitors.

## Comments

Vascular pathologies represent the major cause of ED in the western world. Despite this, vascular workup of ED is rarely performed and endovascular interventions for this frequently encountered condition are still in its infancy. This procedure was shown to be technically feasible in the hands of experienced interventionalists. It is associated with favorable clinical responses along with very low morbidity and mortality rates. The role of specific anti-restenosis therapies such as drug-eluting stents needs further investigation. Generally, the high image quality and low dose settings of the Artis Q angiography system make it the preferred system for this promising procedure. ●

## References

- [1] Baumann F, Hehli D, Makaloski V, Schumacher M, Schönhofen H, Diehm N. Erectile dysfunction – overview from a cardiovascular perspective. *Vasa*. 2017 May 10:1-7.
- [2] Diehm N, Borm AK, Keo HH, Wyler S. Interdisciplinary options for diagnosis and treatment of organic erectile dysfunction. *Swiss Med Wkly* 2015 Dec 28;145:w14268. 145, W14268.
- [3] Rogers JH, et al. Zotarolimus-eluting peripheral stents for the treatment of erectile dysfunction in subjects with suboptimal response to phosphodiesterase-5-inhibitors. *J Am Coll Cardiol* 2012;60:2618–27

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# Quantification of Pulmonary Perfusion in Balloon Pulmonary Angioplasty

---

Courtesy: Sabine Maschke, MD, and Jan Hinrichs, MD, Department of Diagnostic and Interventional Radiology, Hannover Medical School, Germany

## Patient history

A 73-year-old female patient presented to our outpatient clinic with shortness of breath. She had a history of recurrent pulmonary embolism. We suspected she was suffering from chronic thrombo-embolic pulmonary hypertension (CTEPH). During a standard CTEPH workup (right heart catheterization, pulmonary angiography including

C-arm CT), the patient was deemed inoperable and therefore scheduled for balloon pulmonary angioplasty (BPA). The mean pulmonary artery pressure at the beginning of the BPA sessions was 37 mmHg (norm: < 25 mmHg).

## Diagnosis

Inoperable CTEPH

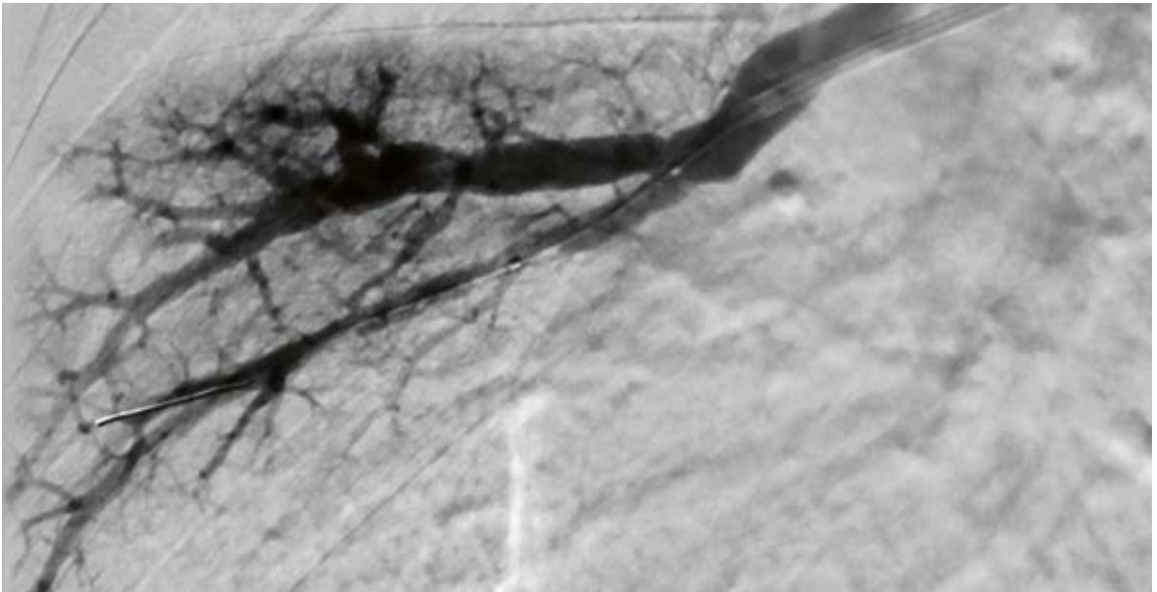


Sabine Maschke, MD, and Jan Hinrichs, MD

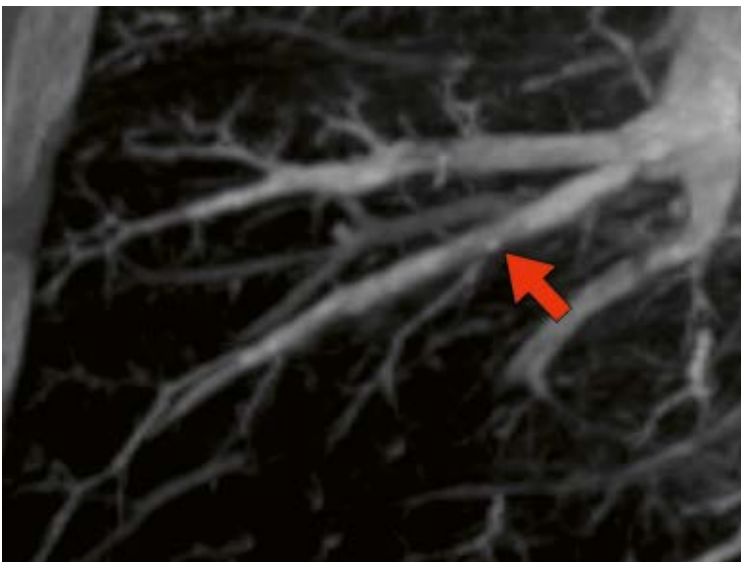
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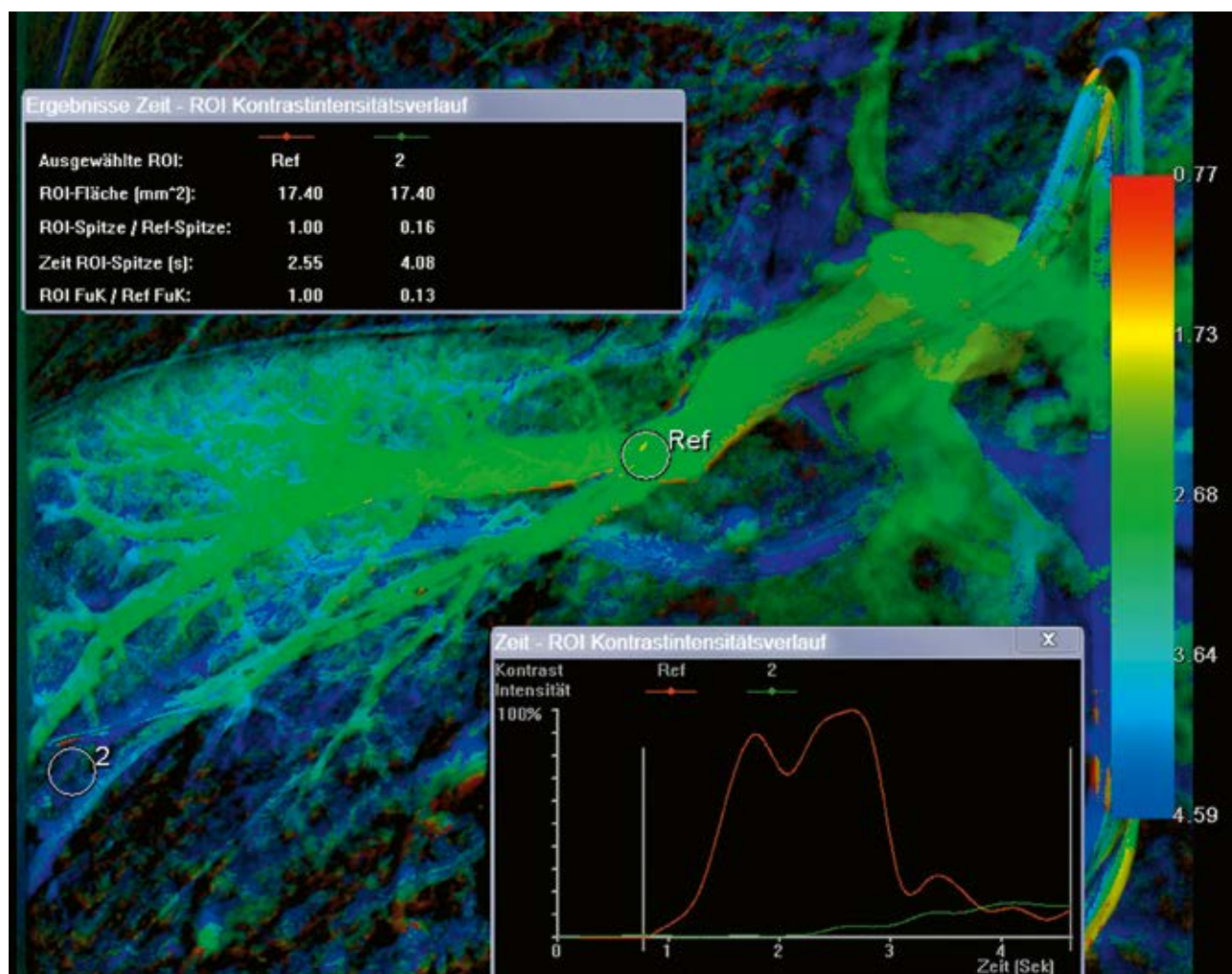
- 1 DSA of the right middle lobe pulmonary artery before (upper image) and after (lower image) BPA.
- 2 Selective C-arm CT of the target pulmonary artery: The left image shows a 20-mm maximum intensity projection in the orientation of the DSA images, and the right image shows the web stenosis.

1



2





3 DSA of the right middle lobe pulmonary artery before BPA, postprocessed using syngo iFlow and showing the proximal reference point and the distal measuring point in the pulmonary parenchyma.

## Treatment

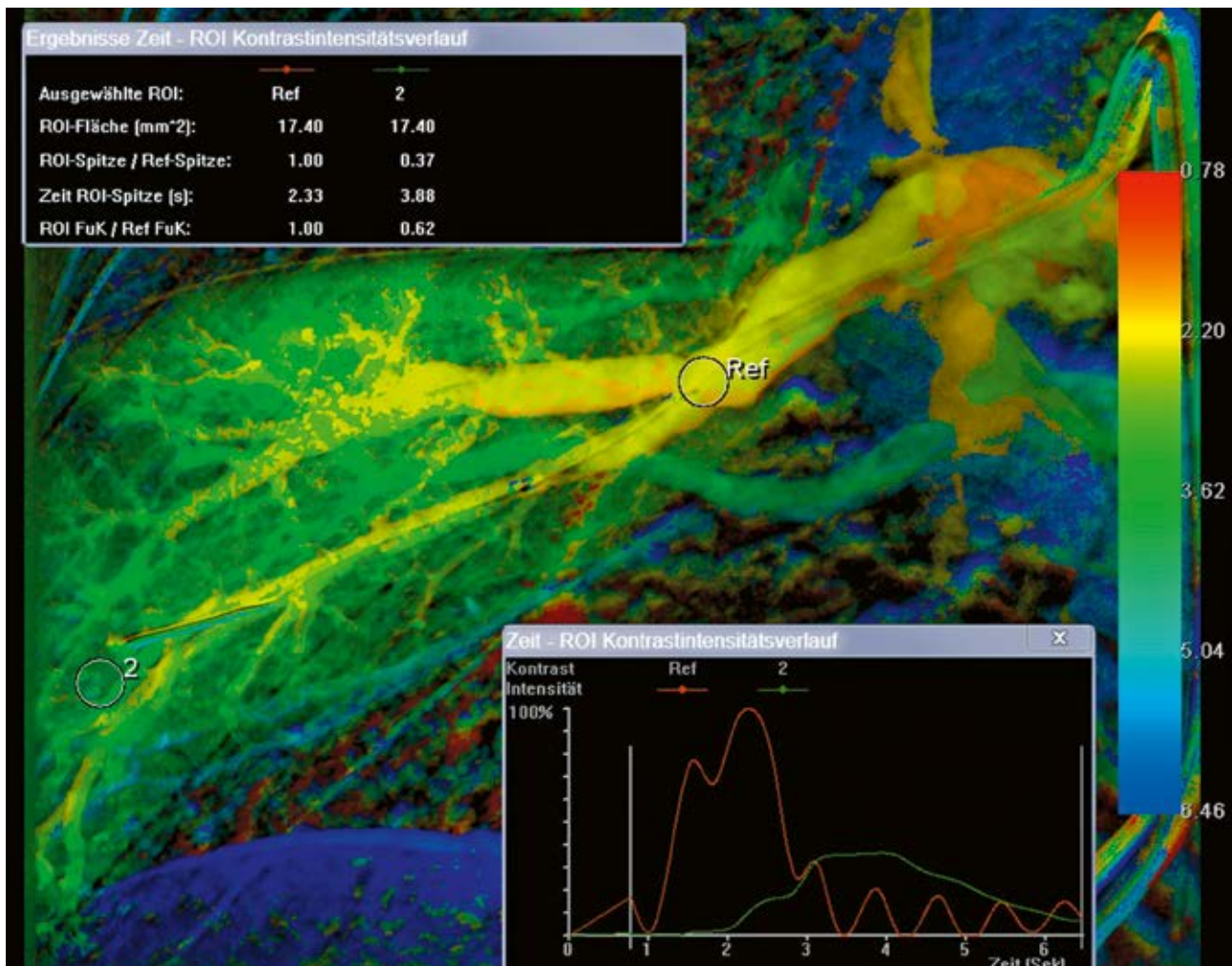
Retrograde access was achieved via the right common femoral vein (long 6F sheath). A selective C-arm CT was performed (6-second DynaCT, Artis Q angiography system) to guide the BPA procedure. A 6F guidance catheter was advanced into the target pulmonary artery segment. A 0.014 inch guidewire was used to cross the web stenosis and dilate using appropriate balloon catheters. Given the sufficient increase in blood flow to the pulmonary artery segment – monitored with digital subtraction angiography (DSA) following BPA – the procedure was

deemed successful. The syngo iFlow application can be used to evaluate angioplasty of the pulmonary vasculature in CTEPH patients.[1] In this case, syngo iFlow was applied to the DSA runs of the pulmonary artery segment before and after BPA to evaluate the success of the intervention. syngo iFlow showed a decrease in time-to-peak for the maximum contrast density measured in the lung parenchyma (pre-BPA: 4.08 seconds; post-BPA: 3.88 seconds) and a clear increase in both peak density (0.16 to 0.37) and in the area under the curve (0.13 to 0.62). This is indicative of improved blood supply and a successful intervention.

A follow-up after six BPA sessions showed improved pulmonary hemodynamics, with mean pulmonary artery pressure dropping significantly from 37 to 27 mmHg, which is consistent with the syngo iFlow results.

## Comments

Clear endpoints for BPA are still lacking. During the intervention, there is no clear indicator of whether the remaining stenosis after BPA is clinically relevant or not. Pressure wires are one way of solving this problem, but they make the intervention more challenging and costly. Quantifying pulmonary perfusion



4 DSA of the right middle lobe pulmonary artery after BPA, postprocessed using syngo iFlow and showing the proximal reference point and the distal measuring point in the pulmonary parenchyma.

before and after BPA using syngo iFlow has been shown to be feasible, and could improve BPA monitoring. syngo iFlow can objectively evaluate a treatment and allow physicians to optimize the result during the intervention.[2]

## Protocol

DSA of pulmonary arteries:  
long 6F sheath in the right common femoral vein; hand injection of 8 mL 70 % iodinated nonionic contrast agent; 4–6 frames/s for 10–30 seconds; comparable injection parameters and delays before and after BPA. ●

## References

- [1] Maschke SK, Renne J, Werncke T, Olsson KM, Hoepfer MM, Wacker FK, et al. Chronic thromboembolic pulmonary hypertension: Evaluation of 2D-perfusion angiography in patients who undergo balloon pulmonary angioplasty. *Eur Radiol*. 2017 Mar; doi: 10.1007/s00330-017-4806-z. [Epub ahead of print]
- [2] Hinrichs JB, Murray T, Akin M, Lee M, Brehm MU, Wilhelmi M, et al. Evaluation of a novel 2D perfusion angiography technique independent of pump injections for assessment of interventional treatment of peripheral vascular disease. *Int J Cardiovasc Imaging*. 2017 Mar; 33(3):295-301. doi: 10.1007/s10554-016-1008-8. Epub 2016 Oct 26.

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# Dynamic 3D Imaging of Peripheral Arteriovenous Malformations

---

Courtesy: Walter A. Wohlgemuth, MD, University Hospital Halle (Saale), Germany<sup>1</sup>

## Patient history

28-year-old female patient with progressive pain and swelling of a warm, pulsatile lesion on the fourth digit of the left hand. Clinical examination and ultrasound suggested a diagnosis of arteriovenous malformation (AVM).

## Treatment

Embolization using a combined percutaneous (direct) puncture and transarterial approach with Onyx®.

## Comments

Standard-of-care imaging for peripheral shunt diseases currently includes preprocedural MR imaging, ultrasound, and interventional 2D digital subtraction angiography (DSA). The use of dynamic 3D imaging to assess contrast dynamics in peripheral AVMs and its value to analyze and treat complex peripheral vascular disorders is currently being explored. The software application *syngo Dyna4D* used here provides a series of consecutive time frames that visualizes the contrast dynamics at each point in time from every angle in a 3D dataset. This helps to overcome the limitations of conventional 2D angiography in terms of resolution of overlapping structures and vessel foreshortening.

## Protocol

5s DSA Head (200 degrees, 1.50 deg/frame, 133 projection images, digital subtraction angiography), no X-ray delay, injection of 19 mL Omnipaque 300 contrast agent, 100 % contrast, 5 mL/s. ●

## Diagnosis

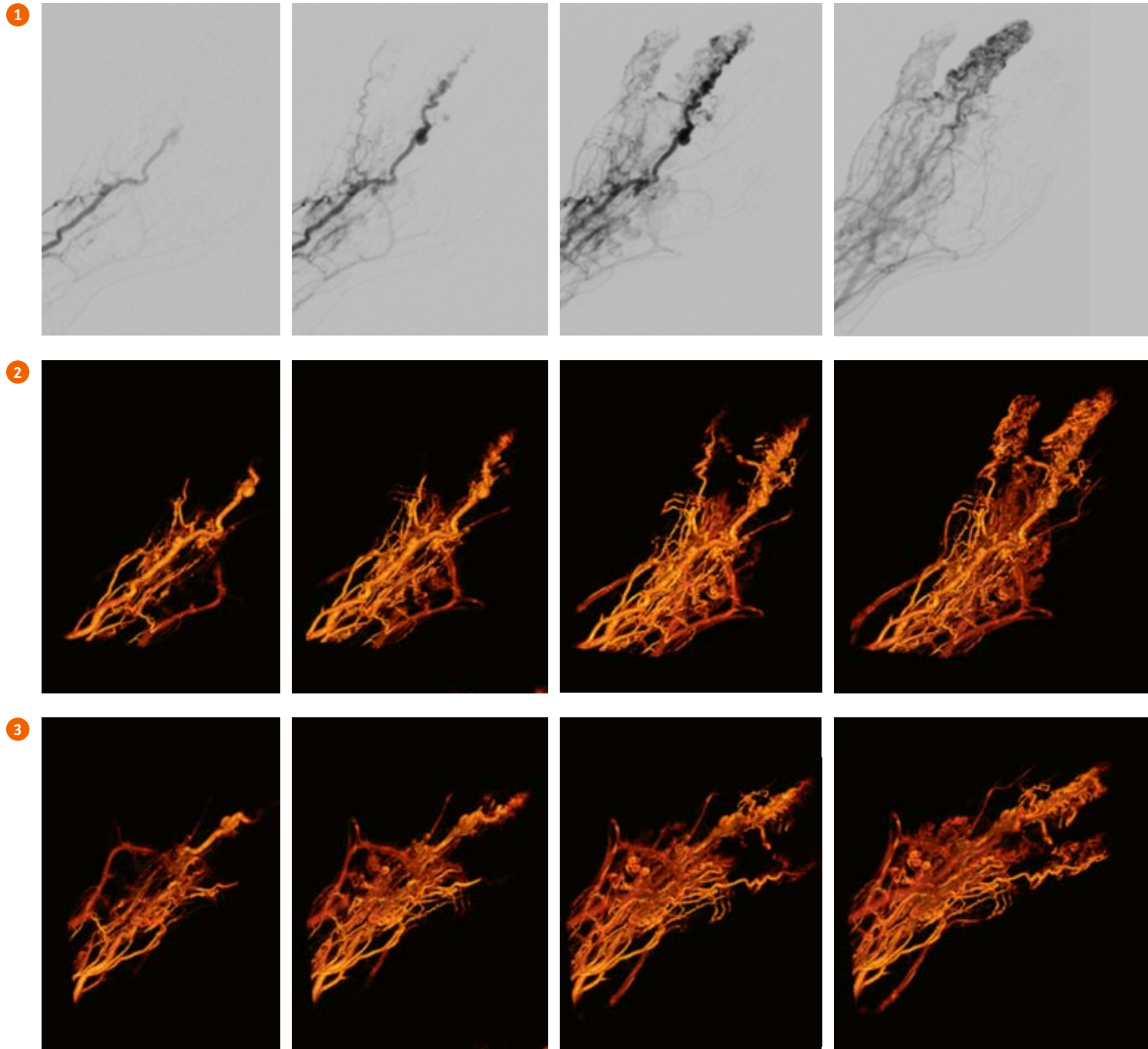
Extensive arteriovenous malformation of the fourth digit of the patient's left hand, with small flow-related aneurysms.



*“syngo Dyna4D can help avoid additional series when analyzing peripheral shunt diseases. It provides a comprehensive, dynamic 3D dataset that allows you to assess complex AVM dynamics from any angle with one injection.”*

Walter A. Wohlgemuth, MD  
University Hospital Halle (Saale), Germany

<sup>1</sup> This case comes from Walter Wohlgemuth's time at the Department of Radiology, University Hospital Regensburg, Germany



- 1 Pre-embolization 2D DSA showing arteriovenous malformation of the left hand.
- 2 Time-resolved 3D image series showing arteriovenous malformation of the left hand (LAO 0°, CAUD 0°).
- 3 Time-resolved 3D image series showing arteriovenous malformation of the left hand (LAO 180°, CAUD 0°).

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# Minimally Invasive Screw Fixation and Osteoplasty of a Pathologic Fracture

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Courtesy: William B. Lea, MD, Department of Radiology, Froedtert Memorial Lutheran Hospital, Milwaukee, Wisconsin, USA

## Patient history

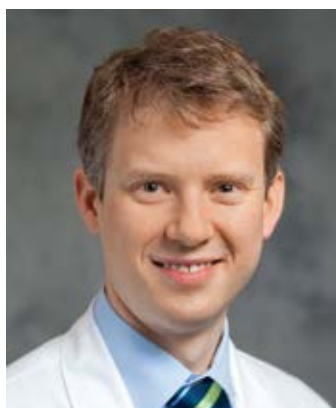
49-year-old male with multiple myeloma presented with a painful pathologic fracture of the left glenoid neck with persistent pain for several months following palliative radiation therapy. CT imaging demonstrated chronic non-union of the fracture which extended across the glenoid neck and involved the suprascapular notch.

## Diagnosis

Multiple myeloma

## Treatment

The aim of the intervention was to relieve pain and improve function by stabilizing the chronic glenoid fracture by using a combination of minimally invasive screw fixation and osteoplasty with polymethylmethacrylate (PMMA). Preprocedural planning consisted of drawing 3D objects on a diagnostic CT scan utilizing the stroke-based segmentation tool. *syngo* Needle Guidance was used to create two screw paths through the scapular body and glenoid body. Utilizing *syngo* Toolbox, a 3D polyline was used to mark the course of the suprascapular nerve. The segmentation tool was used to outline the intended area of PMMA filling within the glenoid defect (Fig. 1). Following intraoperative cone beam CT (*syngo* DynaCT) and 3D/3D registration (*syngo* Fusion package), 3D objects were then projected on real-time fluoroscopy using *syngo* 3D Roadmap for live overlay (Fig. 2). Screw fixation and osteoplasty of the glenoid was then performed using fluoroscopic and 3D overlay guidance. Final screw placement was confirmed using cone beam CT (*syngo* DynaCT) and metal artifact reduction with *syngo* DynaCT SMART.



William B. Lea, MD

## Comments

For this patient, minimally invasive stabilization of the glenoid neck was an attractive option, allowing for adequate stabilization and quick recovery while avoiding disruptions in systemic therapies and operative complications associated with prior radiation therapy. However, several

aspects of this approach presented significant technical challenges including a narrow scapular body screw corridor, proximity of the suprascapular nerve, and potential for PMMA extravasation into the suprascapular notch.

Using the advanced imaging techniques outlined here it was possible

to overcome many of these challenges safely and with confidence.

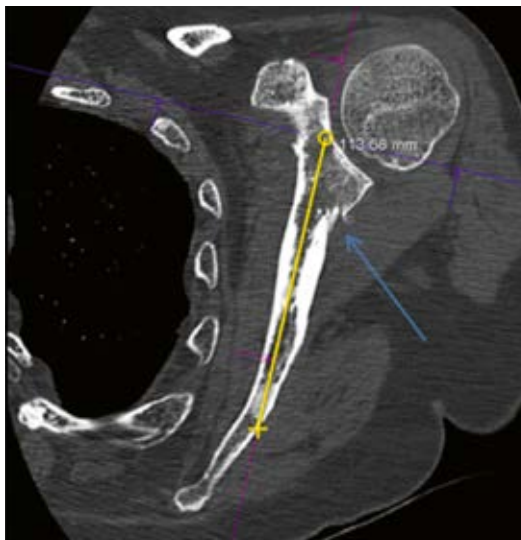
Using preprocedural planning, we were able to determine the exact dimensions of the required screws and ensure their availability ahead of time.

- 1** Preprocedural planning based on a diagnostic CT image: (a+b) Oblique views of the planned screw path (yellow line) along the long axis of the scapula with suprascapular nerve (blue arrow). (c) Screw path for the short axis of the scapula to support the glenoid fossa. (d) Volumetric rendering of the preprocedural plan, visualizing both screw paths and the targeted area for cement injection.

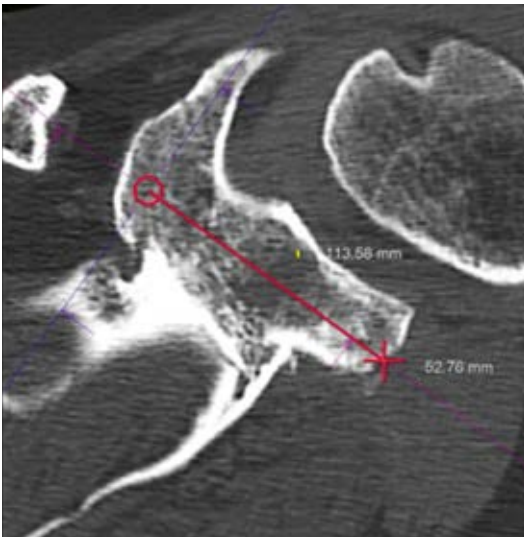
1a



1b



1c



1d



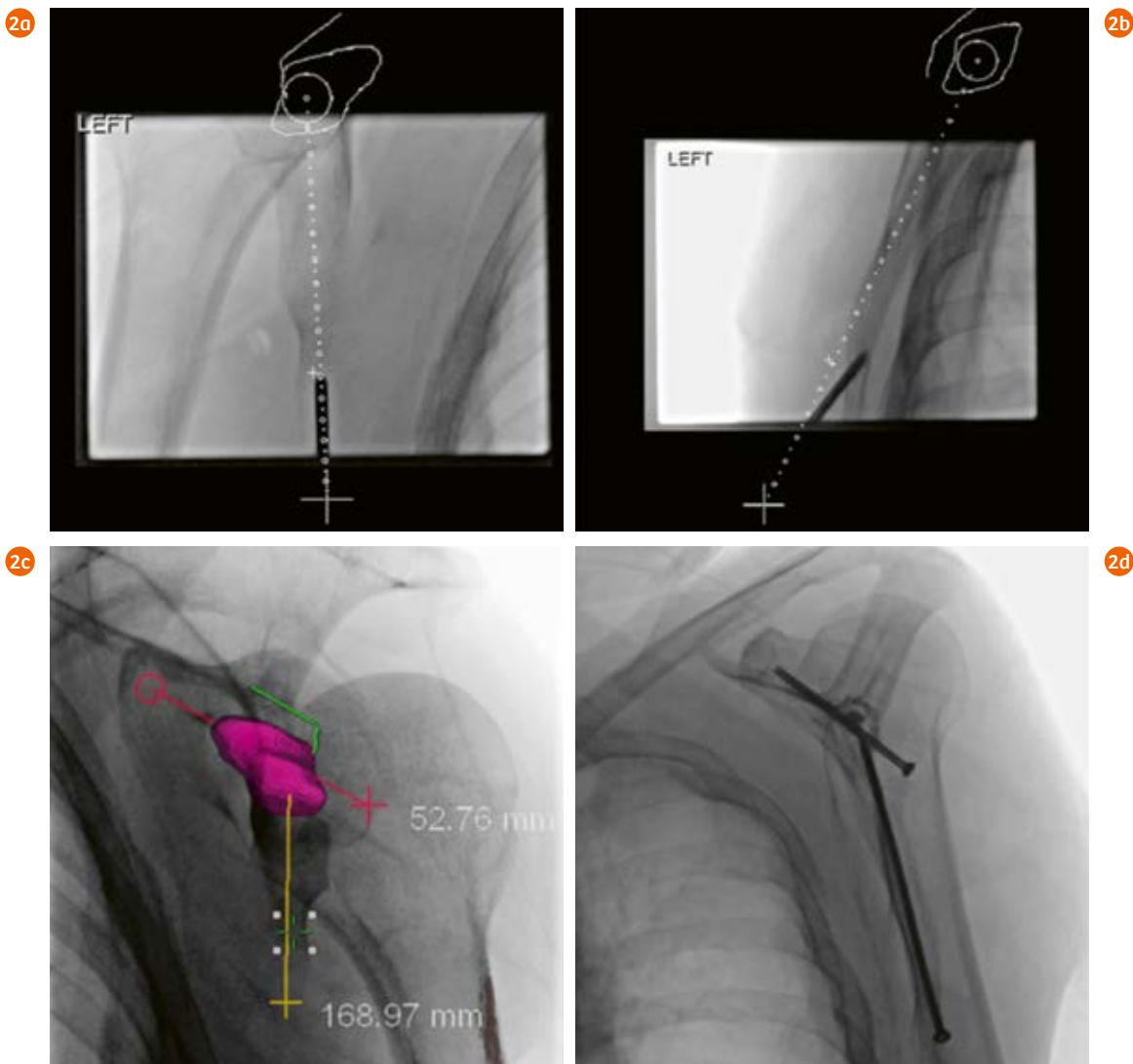
Moreover, our final cone beam CT (*syngo DynaCT*) demonstrates the high degree of precision achievable when placing screws with good registration and live fluoroscopic overlay. It also indicates the advantage of *syngo DynaCT SMART* metal artifact suppression post-implant

(Fig. 3). Threading a screw through the long, narrow corridor of the scapular body is arguably not reliably achievable using conventional methods of fluoroscopy alone in either the angiography suite or operating room.

Additionally, subtle early extension of PMMA outside the contour of

the segmented volume 3D object and toward the suprascapular nerve led to earlier termination of PMMA injection than would likely have occurred using fluoroscopy alone, thereby preventing significant suprascapular notch extravasation and possible nerve entrapment.

- 2 Intraoperative guidance: (a+b) AP and oblique views during placement of bone trocar for scapula access. (c) Overlay of preprocedural planning on live fluoroscopy (displayed on in-room large display). (d) Final screw placement with limited cement injection due to early extravasation outside of targeted volume toward suprascapular nerve.



## Protocol

For planning and fusion to preprocedural CT: 6s DCT Body combined with syngo Needle Guidance; for verification of final product: 6s DCT Body with syngo DynaCT SMART. ●

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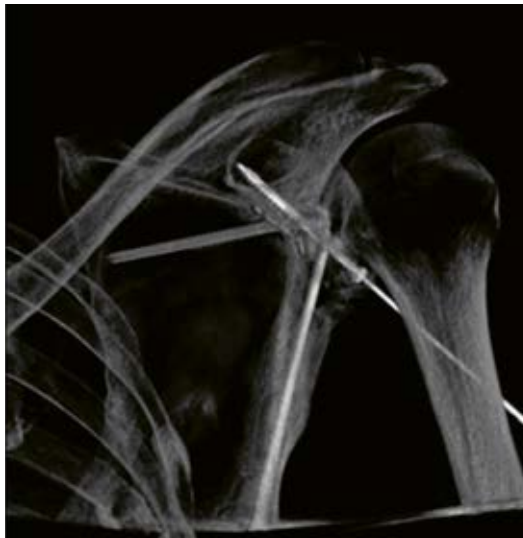
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- 3 Immediate postprocedural assessment: (a+b) Final screw placement in oblique slice positioning and VRT view demonstrating both screws and PMMA. Metal artifacts have been minimized using syngo DynaCT SMART. Comparison of the planned screw path on diagnostic CT scan (c) with the final screw position on CBCT image (d) at the end of the procedure.

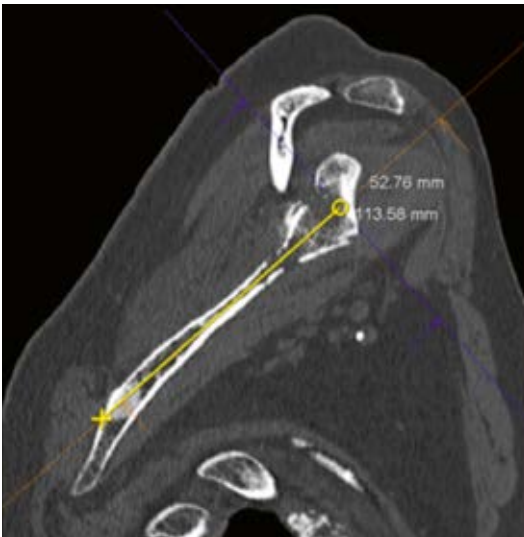
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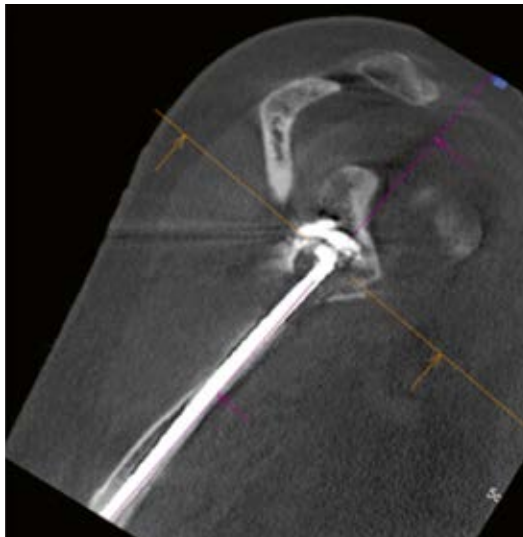
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3c



3d



# Time is Brain

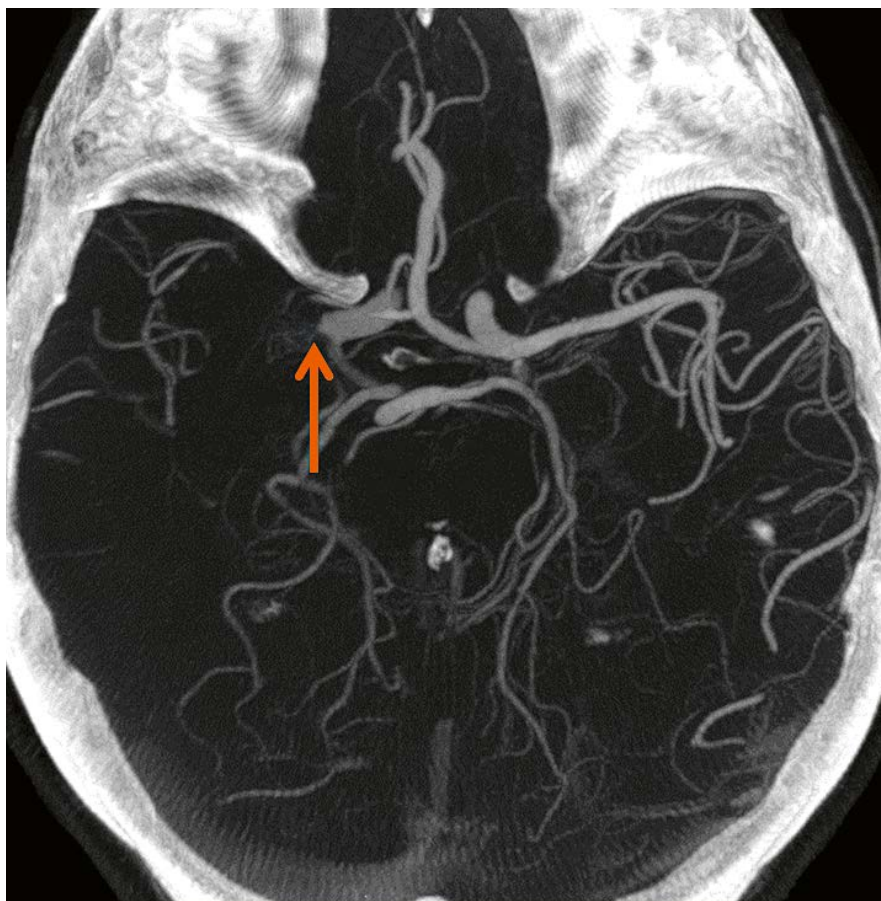
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Regardless of where you are in the world, the most important principle in treating acute stroke is “time is brain”. In 2014, the World Health Organization (WHO) published figures showing 17 million new stroke cases each year of which about six million of these result in death. The World Stroke Organisation (WSO) also says that an estimated 1.9 million neurons can be salvaged with each minute saved in stroke management. This is why rapid treatment is crucial to patient recovery and to subsequent quality of life. A new technology for hospital stroke units could significantly speed up treatment. Recent publications show promising initial results for an angio-only workflow.

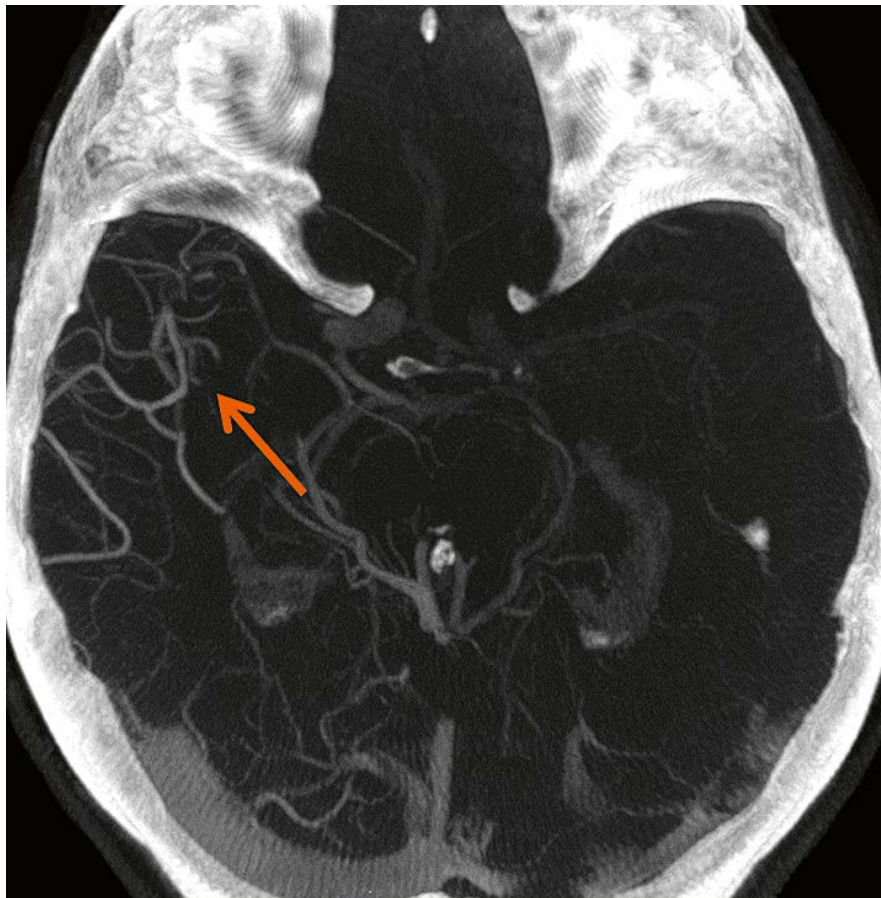
Text: Andrea Lutz

**T**oday's standard stroke workflow involves a neurological exam when the patient arrives at the hospital, followed by transfer to either a computed tomography (CT) or magnetic resonance imaging (MRI) facility for a diagnostic brain scan. This determines whether the patient has suffered a hemorrhagic stroke (bleeding in the brain) or an ischemic stroke (an interruption of the blood supply to the brain caused by a blood clot). Depending on the results, the patient might be sent to the angiography suite for treatment. Thrombectomies are becoming an increasingly

frequent choice for treating ischemic stroke. Together, all these steps can put 130 minutes between the patient's arrival at the hospital and reperfusion of the brain. In order to save time, the first logical step is to bring diagnosis (CT/MRI) and treatment (angiography) closer together – ideally into the same room. A combined solution consisting of a CT and an angio system, is starting to attract market attention in this specific field. Angio-CTs provide the potential to save valuable time and are expected to gain traction at stroke centers around the world.



**Early phase –  
occlusion of right middle  
cerebral artery**



**Late phase –  
delayed collaterals**

Highly detailed image quality is critical in assessing stroke patients and supports safe and efficient vascular interventions. It can be achieved in the angio suite with a single intravenous contrast injection.

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*“The ability to image and treat stroke patients in the same room [...] results in a door-to-groin time of 23 minutes, and a door-to-reperfusion time of 59 minutes.”*

Marios Psychogios, MD  
University Medical Center Goettingen,  
Germany

## Interventional treatment is preferred

In recent years, several studies have focused on thrombectomy in stroke treatment. MR CLEAN, a multi-center randomized clinical trial, proved that interventional treatment is the preferred choice in many stroke cases.[1] The study comes to the following conclusion: “Our results show that patients with acute ischemic stroke (...) benefit with respect to functional recovery when intra-arterial treatment is administered within six hours after stroke onset. This treatment leads to a clinically significant increase in functional independence in daily life by three months, without an increase in mortality. Our findings stand in clear distinction to those of recent randomized, controlled trials that failed to show the benefit of intra-arterial treatment.”

## One-stop stroke management

MR CLEAN and all subsequent trials amply demonstrate the overwhelming efficacy of intra-arterial treatment for acute ischemic stroke. A combined solution might not be necessary in every case, because patients who score highly on the National Institute of Health Stroke Scale (NIHSS) could be taken directly to the angio suite for diagnosis with a DynaCT run and receive immediate endovascular treatment if necessary. This is why an angio-only stroke workflow opens up new and exciting potential for shortening door-to-groin times. The stroke research group headed by Marios Psychogios, MD, in Göttingen, Germany, has produced very promising early results.[2]

## Shorter door-to-groin times

The Göttingen team developed and implemented a one-stop approach to stroke management which bypasses the usual multidetector CT (MDCT) scan. Patients presenting with an NIHSS score  $\geq 7$  (as of January 2017) are transferred straight to the angio suite. They are examined with a cone-beam CT and treated by endovascular means in the event of a large vessel occlusion. The Göttingen team began using the approach with transfer patients back in January 2016. Since most of these patients were treated with thrombolysis during transport to the comprehensive stroke center, repeated imaging was justified to exclude an intracranial hemorrhage. The next step was to use the approach with direct-admission patients, which the team began doing in June 2016. At first, they only applied it to patients with an NIHSS score  $\geq 10$ . Thirty patients were treated in this way. The findings are currently under review, but the initial experience shows that the team significantly reduced door-to-groin times while successfully differentiating ischemic from hemorrhagic stroke. In January 2017, the team lowered the threshold for one-stop management to an NIHSS score of  $\geq 7$ .

Psychogios draws a promising preliminary conclusion: “We’ve demonstrated to the best of our knowledge the first direct admission stroke patients triaged and treated in the angio suite with one-stop management. The ability to image and treat stroke patients in the same room without needing to transport them between modalities resulted in a door-to-groin time of 23 minutes, and a door-to-reperfusion time of 59 minutes. Both times are below the recently propagated ideal target intervals of 60 minutes and 90 minutes for door-to-groin and door-to-reperfusion.”



syngo DynaCT with angiography helps to rule out hemorrhage, check clot location and collateral status, while perfusion analysis with syngo DynaPBV Neuro is used to evaluate the size and location of the infarct core. This unique combination of angio and CT supports a faster decision on whether interventional treatment is advisable or not.

## Will angio-only prevail?

Angio-only is a promising approach to optimizing the management of stroke patients. It could soon find itself on an equal footing with the established modality, because it benefits both patients and hospital administrators. For patients, faster treatment and short intervals between hospital admission and reperfusion are expected to positively influence clinical outcomes. For hospitals, in many cases the angio-only workflow could mean not having to transfer patients from the conventional CT scanner to the angio suite. This would make logistics and coordination much simpler – a clear advantage in terms of cost efficiency. ●

**Andrea Lutz** is a journalist and business trainer specializing in medicine, technology, and healthcare IT. She lives in Nuremberg, Germany.

## References

- [1] Berkhemer OA, Fransen PS, Beumer D, van den Berg LA, Lingsma HF, Yoo A, et al. A randomized trial of intraarterial treatment for acute ischemic stroke. *N Engl J Med*. 2015; 372(1): 11-20.
- [2] Stroke Research Group Göttingen (GER). One Stop in Stroke [Internet]. Göttingen (Germany): Stroke Research Group Göttingen; [cited August 2017]. Available from: <http://onestopinstroke.eu/>.

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# Time-resolved Three-dimensional Imaging in DAVF/AVM Radiosurgery Therapy Planning

Courtesy: Professor Wan-Yuo Guo, MD, PhD, Department of Radiology, Taipei Veterans General Hospital, Taiwan

## Patient history

A study was conducted of twenty consecutive patients diagnosed with cerebral shunt diseases: 8 patients had dural arteriovenous fistula (DAVF), 12 patients presented with arteriovenous malformations (AVMs). In the study cohort of 13 men and 7 women, the overall mean age was 45 years (range: 18–66 years). In male patients, the mean age was 48 years (range: 18–66 years), whereas female patients presented with a mean age of 47 years (range: 32–64 years). All patients underwent stereotactic radiosurgery (SRS) dose planning with Advanced Leksell GammaPlan®

and radiosurgery treatment with Gamma Knife®. Four patients (1 DAVF, 3 AVMs) were retrospectively excluded due to incomplete coverage of the stereotactic markers in the angiographic image field of view.

## Diagnosis

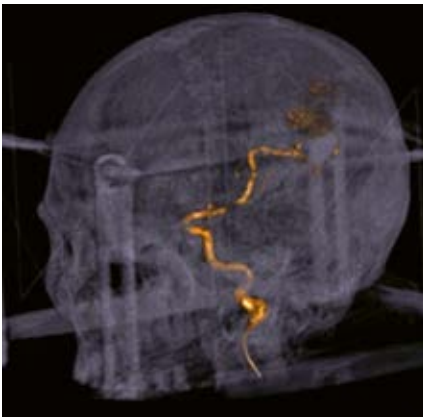
Cerebral shunt diseases (8 patients with DAVF, 12 patients with AVMs).

## Treatment

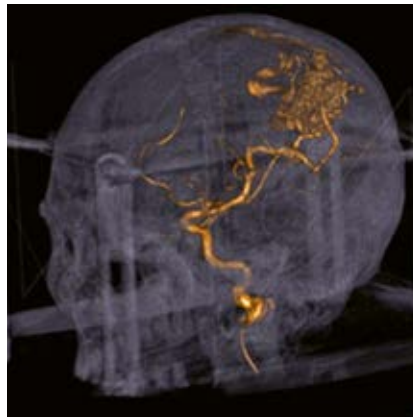
All patients underwent SRS planning with Advanced Leksell GammaPlan®. Integrated stereotactic imaging

included MR imaging and two-dimensional digital subtraction angiography (2D DSA). In addition, time-resolved three-dimensional imaging (syngo Dyna4D) was included to retrospectively evaluate the potential role of time-resolved 3D DSA in SRS planning. For dose planning, a single optimal phase of the nidus/fistula opacification was selected from the 4D volume for each patient and sliced along the cranial-caudal direction (3 mm slices without interspacing) into 2D CT-like images (MPR ranges). 2D CT-like images were then tagged with CT DICOM header information and transferred to GammaPlan®.

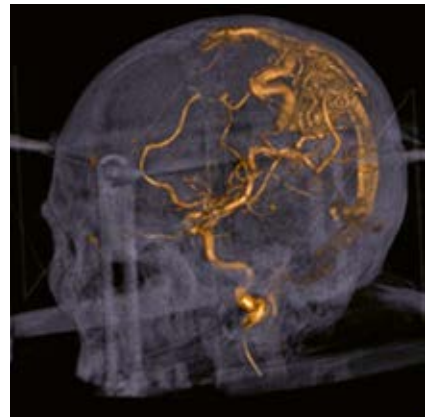
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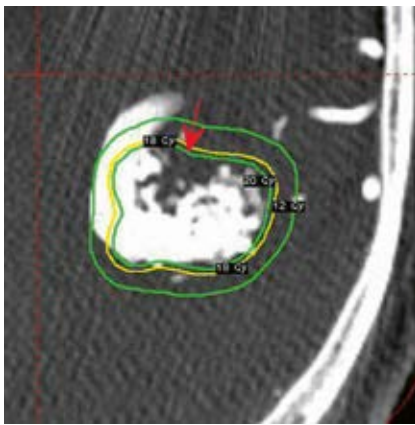


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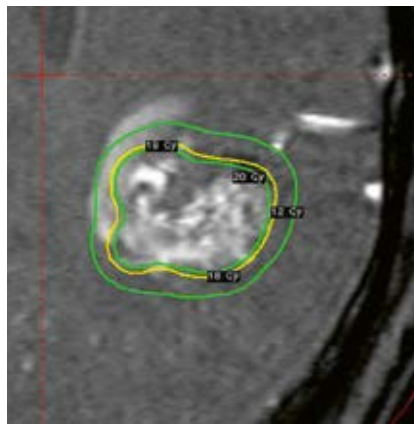


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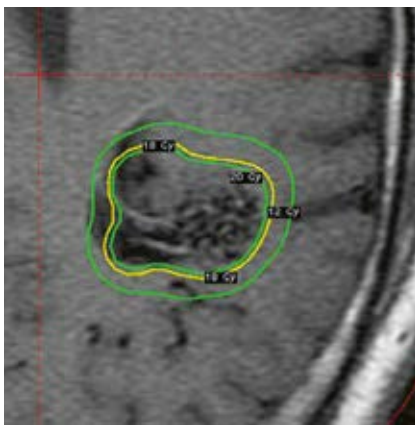




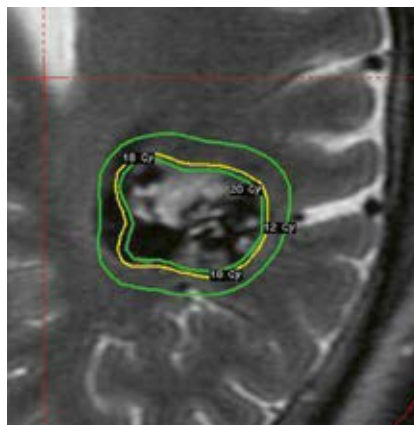
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- 1 Early opacification phases of the AVM nidus; only the feeding artery and a portion of the nidus are opacified.
- 2 Middle opacification phases of the AVM nidus; both the feeding artery and nidus are opacified, as well as a portion of the draining vein. This phase is optimal for nidus delineation.
- 3 Late opacification phase; the draining veins are completely opacified and may obstruct the visibility of the nidus.
- 4 Time-resolved 3D DSA of a 53-year-old man with a larger and more intricate AVM. Isodose contours are retrieved from original treatment planning. The red arrow indicates a non-nidus territory considered part of the AVM nidus and enclosed within the irradiated volume based on the integrated MR images.
- 5 Corresponding TOF MR imaging section.
- 6 T1-weighted MR image shown on the same axial location.
- 7 T2-weighted MR image shown on the same axial location.

After image registration with the digital phantom from the localization box, the original treatment plans based on the MR/2D DSA images were overlaid to evaluate the radiation coverage of the nidus/fistula depicted by time-resolved 3D DSA.

## Comments

Current imaging approaches for SRS treatment planning combine MR imaging and 2D DSA. The clinical study presented here, however, demonstrated that time-resolved 3D DSA has potential to improve DAVF/AVM SRS planning by providing hemodynamic and morphological information in one step. For the cases included in this study, it has been shown that time-resolved 3D DSA provides a better delineation of the

AVM nidus than 2D DSA, particularly for larger and intricate nidi. It also provides higher temporal and spatial resolution than current MR imaging and CT angiography. In AVM treatment planning, final contours derived from time-resolved 3D DSA were generally smaller than those derived by MR. In one case (Fig. 4), the 3D DSA image clearly identified normal brain tissue that had been mistaken for vascular structures on the MR image.

## Protocol

12s Dyna4D Head (12 seconds, 260 degrees, 304 projection images, digital subtraction angiography), 0.5 second X-ray delay, injection of 24–41 mL Omnipaque 300 contrast agent, 100 % contrast, 3 mL/second. ●

## Reference

Chen KK, Guo WY, Yang HC, Lin CJ, Wu CF, Gehrisch S, Kowarschik M, Wu YT, Chung WY. Report of Application of Time-Resolved 3D Digital Subtraction Angiography to Plan Cerebral Arteriovenous Malformation Radiosurgery. *AJNR Am J Neuroradiol.* 2017 Apr;38(4):740-746. doi: 10.3174/ajnr.A5074.

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# Planning Anterograde and Retrograde Embolization Treatment of Arteriovenous Malformation

Courtesy: Professor Charbel Mounayer, Interventional Neuroradiology Department, Dupuytren University Hospital, Limoges, France

## Patient history

The patient experienced post-critical confusion following a tonic-clonic seizure lasting several minutes. He was immediately transferred to the nearest emergency department. The patient presented with spatio-temporal disorientation but no sign of sensory or motor deficits (Glasgow 15)<sup>1</sup>.

## Diagnosis

A CT scan performed in the emergency department showed a right parieto-occipital hemorrhage of about 24 mm in diameter and a perilesional edema. A left frontal lesion with serpiginous contrast was also identified, suggesting an arteriovenous malformation (AVM). The patient was then transferred to Dupuytren University Hospital in Limoges for further examination and treatment.

Selective 2D biplane subtracted angiography of the cerebral trunks using a percutaneous femoral approach revealed two malformations:

- First, a left anterior internal frontal artery (AIFA) malformation with cortical venous drainage, mainly fed by the AIF branch of the left anterior cerebral artery. This malformation presented double venous drainage indicating a gyral character (main drainage from the frontal anterior internal cortical vein and accessory drainage from the middle cortical vein, both connected to the superior longitudinal sinus). This malformation did not have any intranidal aneurysms.
- Second, a right temporal pial malformation with the presence of an intranidal aneurysm, 6 to 7 mm at its widest, heavily implicated in the recent bleeding. Its venous drainage was deep. Through a temporal vein, it joined the basal vein of Rosenthal, Galen's ampulla, and the right sinus.

4D digital subtracted angiography (syngo Dyna4D) of the arterial pedicles was performed to clarify the angioarchitecture of these two malformations. 36 mL of contrast medium was injected at a flow rate of 3 mL/s into the ipsilateral internal carotid artery with no delay with the injection or radiation.

## Treatment

A decision was made to exclude both malformations using an endovascular approach. Imaging support during embolization was provided by an Artis zee biplane system.

Under general anesthetic, a bilateral femoral approach was prepared using a 6 Fr introducer inserted into the right femoral artery and a 4 Fr introducer inserted into the left femoral artery. The left femoral artery was used only for blood pressure monitoring. Given its filiform aspect, a 6 Fr catheter was used in the right internal carotid artery for the right temporal AVM.

<sup>1</sup> Glasgow Coma Scale Assessment is a scale used to define the level of consciousness between 3 (deep unconsciousness) and 15 (normal conscious level) developed at the University of Glasgow's Institute of Neurological Sciences.

1



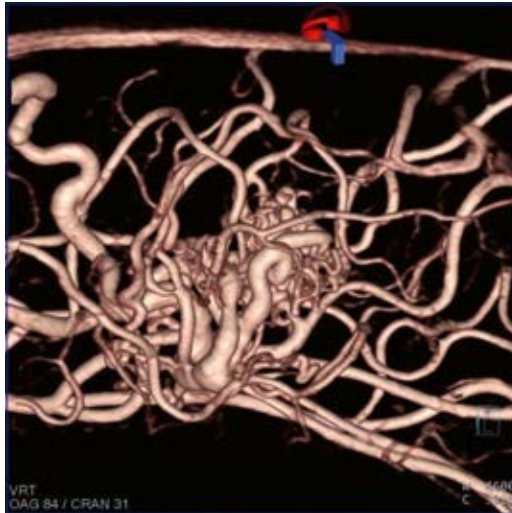
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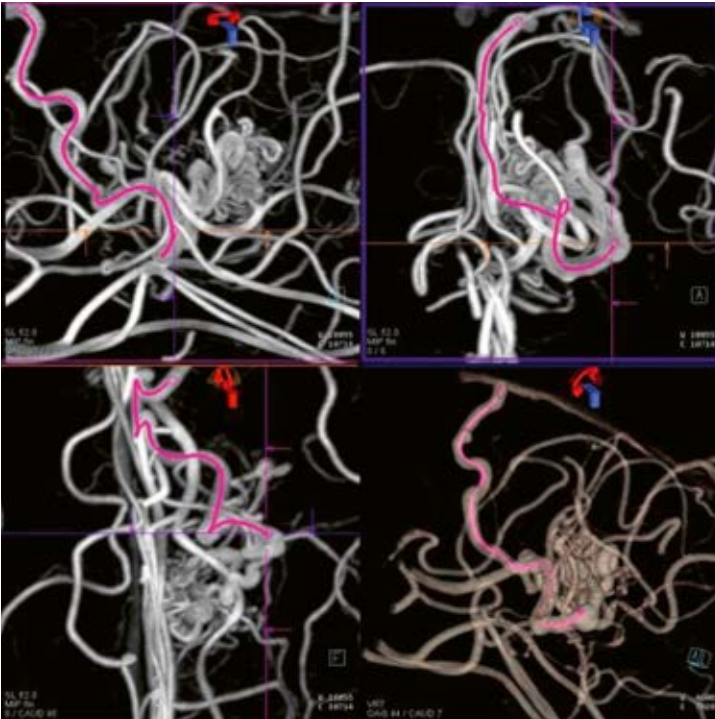
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- 1 Axial view of the CT scan performed in the emergency department: Right parieto-occipital hemorrhage.
- 2 Artis zee biplane angiography system at Dupuytren University Hospital, Limoges, France.
- 3 2D digital subtracted angiography: The lateral view shows two AVMs.
- 4 syngo Dyna4D image shows nidus and trifurcation of the drainage vein of the left anterior internal frontal malformation.
- 5 syngo Dyna4D MIP and VRT reconstructions and retrograde trajectory calculations with syngo Embolization Guidance for drainage vein embolization.

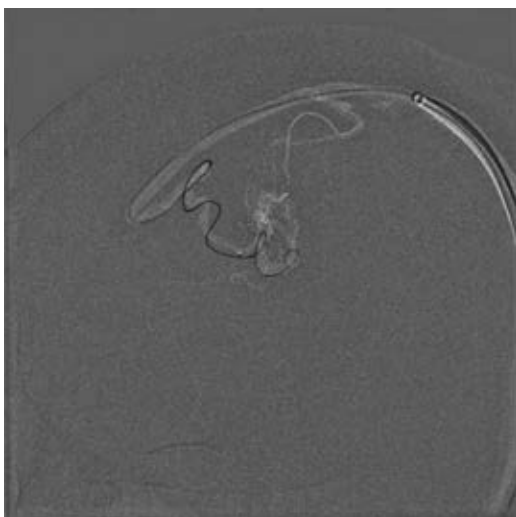
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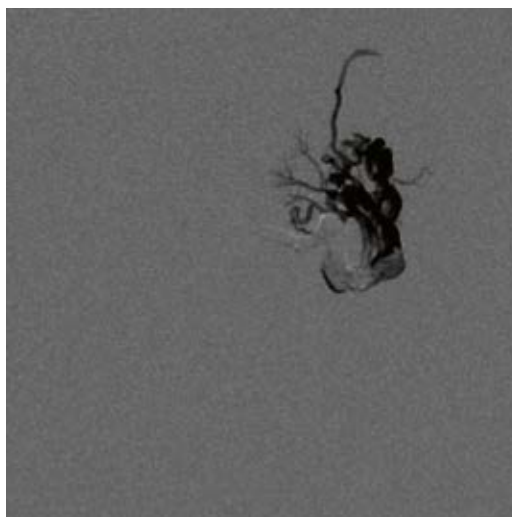
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- 6 2D digital subtracted angiography shows supraselective catheterization of the right temporal pial malformation.
- 7 2D digital subtracted angiography shows supraselective antegrade catheterization of the left anterior internal frontal malformation.
- 8 DSA Roadmap: Retrograde supraselective catheterization of the internal frontal cortical vein draining the malformation.
- 9 Complete exclusion of nidus and drainage veins with Onyx 18 glue.
- 10 Complete exclusion of the left anterior frontal AVM.
- 11 Final DynaCT 20s run with metal artifact reduction.

A MAGIC microcatheter introduced coaxially was used with a 50 % biological glue injection for supra-selective catheterization of the malformation. Navigation with a detachable microcatheter was not possible due to the small supplying vessels.

During catheter removal, a small vascular rupture was visible on the syngo Roadmap images as a small localized sulcal hemorrhage, but without any diffusion.

The same catheter then allowed selective catheterization of the left internal carotid artery to treat the left frontal AVM, whose nidus zone had been measured at between 2.5 cm and 3 cm at its widest. After selective catheterization of the left anterior internal frontal branch using an Apollo™ 1.5-cm detachable microcatheter, a venous approach was simultaneously performed by direct puncture of the right jugular vein (6 Fr introducer), a 6 Fr catheter (Benchmark) and a selective

catheterization of the internal frontal cortical vein, draining the malformation, with a Marathon™ microcatheter.

A retrograde injection (venous approach) of Onyx™ 18 was used until the primary veins were completely filled and a large part of the nidus excluded. An antegrade injection (arterial approach) of Onyx 18 was then used until complete exclusion of the nidus and an accessory drainage vein.

The final biplane 2D subtracted control image confirmed complete exclusion of the AVM. Cone beam CT (20 sec syngo DynaCT) performed at the end of the treatment revealed no hemorrhagic complications.

Acquisition protocol	12s Dyna4D Head
Injection protocol	
Dilution	No (pure contrast medium)
Injection volume	36 mL
Injection rate	3 mL/s into the ipsilateral internal carotid artery
Duration of injection	12 s
X-ray delay	No
Injection delay	No

Final comments and follow-up

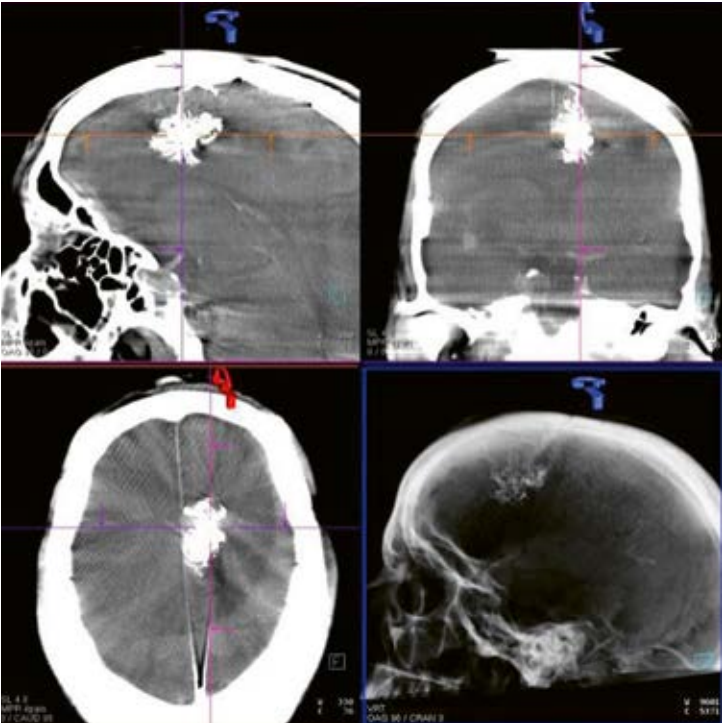
A right temporal pial AVM was successfully treated via endovascular embolization with biological glue (Onyx 18). Total exclusion of the nidus and the intranidal aneurysm was achieved. Furthermore, a left frontal AVM was successfully embolized using an antegrade and retrograde approach with biological glue (Onyx 18).

In accordance with established protocol, an angiographic follow-up will be carried out 6 months after treatment. ●

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# Upcoming Congresses 2017/2018

We offer the opportunity to meet us at international congresses, trade fairs, and workshops. Below is a list of key events where you can meet experts and learn more about interventional radiology from Siemens Healthineers.

Title	Location	Short Description	Date	Contact
RSNA	Chicago, USA	Radiological Society of North America	Nov 26 – Dec 01	<a href="http://www.rsna.org">www.rsna.org</a>
ISC	Los Angeles, USA	International Stroke Conference	Jan 24 – 26	<a href="http://www.professional.heart.org">www.professional.heart.org</a>
Arab Health	Dubai, UAE	Arab Health	Jan 29 – Feb 01	<a href="http://www.arabhealthonline.com">www.arabhealthonline.com</a>
LINC	Leipzig, Germany	Leipzig Interventional Course	Jan 30 – Feb 02	<a href="http://www.leipzig-interventional-course.com">www.leipzig-interventional-course.com</a>
ECR	Vienna, Austria	European Society of Radiology	Feb 28 – Mar 04	<a href="http://www.myesr.org">www.myesr.org</a>
LINNC US	New York, USA	Interventional Neuroradiology and Neurosurgery Community	Mar 16 – 17	<a href="http://www.linnc.com">www.linnc.com</a>
SIR	Los Angeles, USA	Society of Interventional Radiology	Mar 17 – 22	<a href="http://www.sirweb.org">www.sirweb.org</a>
ITEM	Yokohama, Japan	International Technical Exhibition of Medical Imaging	Apr 13 – 15	<a href="http://www.j-rc.org">www.j-rc.org</a>
ECIO	Vienna, Austria	European Conference on Interventional Oncology	Apr 22 – 25	<a href="http://www.ecio.org">www.ecio.org</a>
WLNC	Kobe, Japan	World Live Neurovascular Conference	Apr 25 – 27	<a href="http://www.wlnc.org">www.wlnc.org</a>
DRK	Leipzig, Germany	Deutscher Röntgenkongress	May 09 – 12	<a href="http://www.2018.roentgenkongress.de">www.2018.roentgenkongress.de</a>
GEST	Miami Beach, USA	Global Embolization Symposium and Technologies	May 17 – 20	<a href="http://www.gestweb.org">www.gestweb.org</a>
WCIO	Boston, USA	World Conference on Interventional Oncology	Jun 07 – 10	<a href="http://www.io-central.org">www.io-central.org</a>
SNIS	San Francisco, USA	Society of NeuroInterventional Surgery	Jul 23 – 27	<a href="http://www.snisonline.org">www.snisonline.org</a>
CIRSE	Lisbon, Portugal	Cardiovascular and Interventional Radiological Society of Europe	Sep 22 – 26	<a href="http://www.cirse.org">www.cirse.org</a>
JFR	Paris, France	Journées Francophones de Radiologie	Oct 13 – 16	<a href="http://www.sfrnet.org">www.sfrnet.org</a>
SVIN	Boston, USA	Society of Vascular and Interventional Neurology	Nov 08 – 11	<a href="http://www.svin.org">www.svin.org</a>
RSNA	Chicago, USA	Radiological Society of North America	Nov 25 – 30	<a href="http://www.rsna.org">www.rsna.org</a>

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