ASSIST MAGAZINE

Innovative Interventional Treatments

GROWING THE IR/IO DEPARTMENTS WITH NEW TECHNOLOGIES

AUGMENTED CBCT FOR NEURO

New interventional care pathways with augmented cone beam CT

Magazine#9

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Dear Reader,

The utility of cone beam CT (CBCT) has been demonstrated in multiple care pathways including neurovascular disease, vascular disorders and oncology. However, the technology is still under-used due to the perceived complexity of the room and patient setup to acquire a 3D spin and concern about potential additional radiation dose and contrast.

In this edition of the ASSIST magazine, we aim to gather the experience of several users around the world to not only demystify the use of CBCT, but also to show how the CBCT unlocks a new horizon of augmented imaging for better patient outcomes.

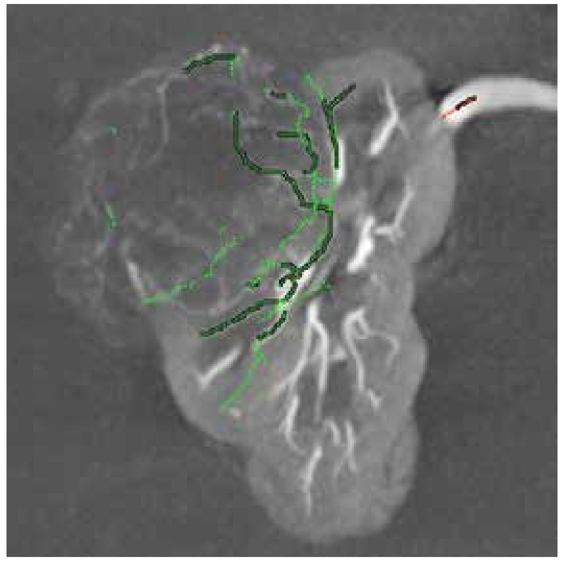
Augmented CBCT is easily translatable to most of IR treatments targeting benign pathologies (kidney angiomyolipoma, prostate hyperplasia), and also applicable in more acute settings. The experts in the magazine envision a bright future for interventional radiology with a multitude of applications to explore: knee osteoarthritis, combination of embolisation with immunotherapy, percutaneous injection of engineered oncolytic virus into metastases, etc.

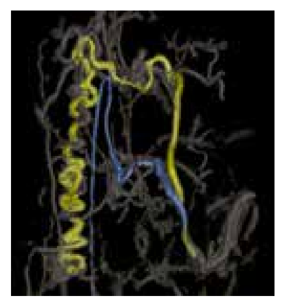
Neuroradiology also benefits from the augmented CBCT as demonstrated further in the magazine, in combination with open surgery or to help assess the best course of treatment after a diagnostic exam. Finally, the augmented reality is showcased as part of the standardised approach to the endovascular treatment of lower limb occlusions in a French centre.

We would like to thank our clinical partners for sharing their vision and their best practices in this ASSIST magazine and wish you a good reading!

Cecilia Felix and Emmanuelle Majus

ASSIST MAGAZINE





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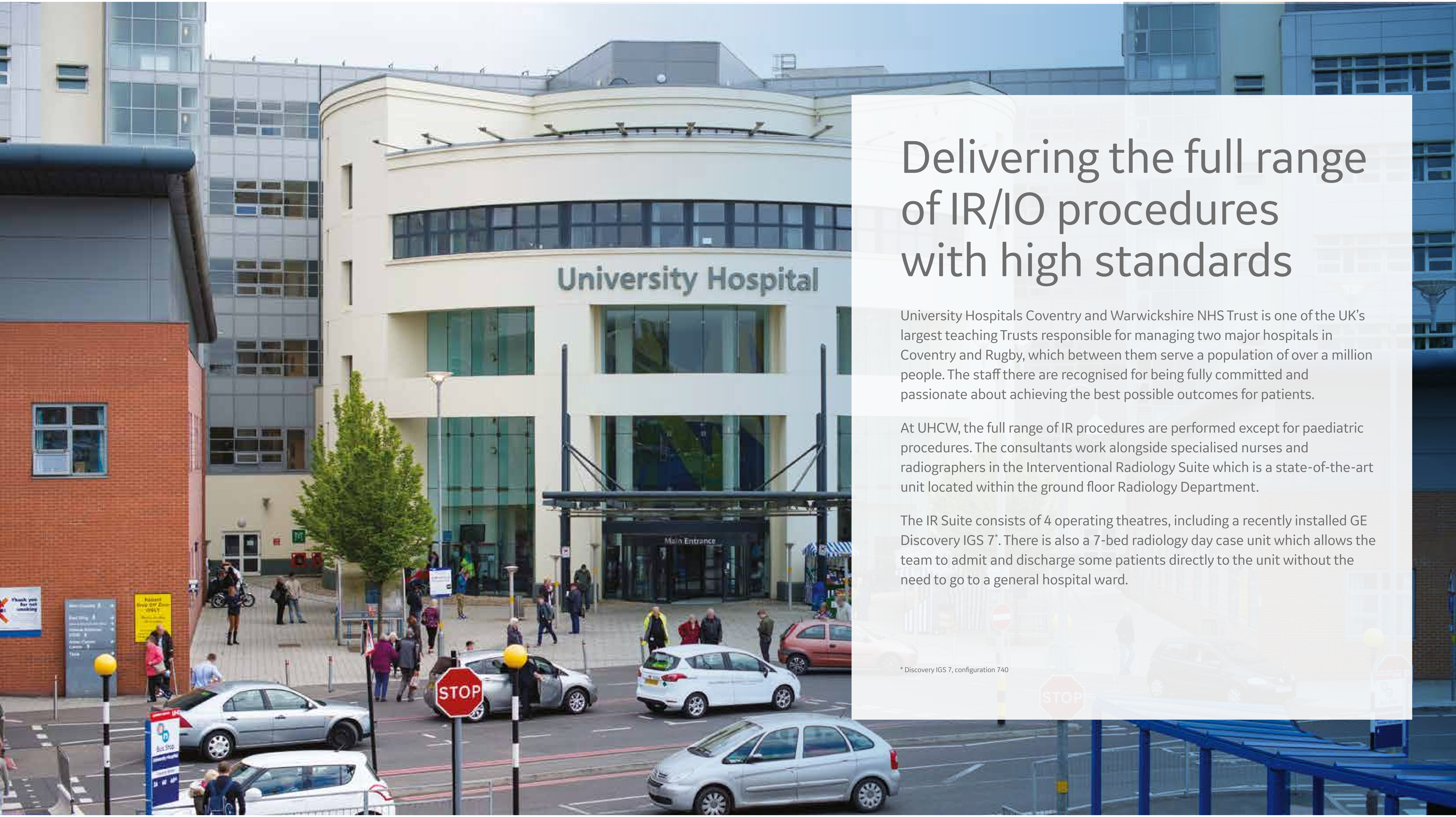
Growing IR/IO departments



Delivering the full range of IR/IO procedures with high standards

University Hospitals Coventry and Warwickshire NHS Trust is one of the UK's largest teaching Trusts responsible for managing two major hospitals in Coventry and Rugby, which between them serve a population of over a million people. The staff there are recognised for being fully committed and passionate about achieving the best possible outcomes for patients.

At UHCW, the full range of IR procedures are performed except for paediatric procedures. The consultants work alongside specialised nurses and radiographers in the Interventional Radiology Suite which is a state-of-the-art unit located within the ground floor Radiology Department.

The IR Suite consists of 4 operating theatres, including a recently installed GE Discovery IGS 7*. There is also a 7-bed radiology day case unit which allows the team to admit and discharge some patients directly to the unit without the need to go to a general hospital ward.

* Discovery IGS 7, configuration 740

Dr James Harding is an Interventional Radiologist at UHCW. His main interest is embolisation and Interventional Oncology, including liver TACE. He has been involved in starting numerous new services at UHCW including RIG, TACE, UAE, PAE and using Onyx for endoleaks.

He has worked actively performing and promoting Prostate Artery Embolisation (PAE) for men with obstructive urinary symptoms and acted as the Principle Investigator at UHCW in one of the top five contributing centres in the national UKRoPE* study, the first multi-centre research into PAE in the UK.

Dr Neil Gupta is an Interventional Radiologist at UHCW. His IR interests are wide and he performs a huge variety of procedures with particular interest in UAE, varicocele embolisation, RIG, PTC, nephrostomy & ureteric stenting, angioplasty, fistuloplasty, complex biopsy/ drainage and embolisation.

He has also brought skills in endovascular thrombectomy and set up the local service, particularly for thrombosed dialysis fistulas.

*https://pubmed.ncbi.nlm.nih.gov/29645352/

Embolisation is the future of Interventional Radiology

The radiology team at UHCW covers all areas of general IR: chest, abdomen, pelvis, the aorta and peripheral vascular diseases. With such a busy hospital and a limited number of staff, the 4.5 full time equivalent consultants have to maintain a broad practice of IR, from non-vascular work (urology, biliary, standard drainages) to complex embolisations (PAE, TACE). The team of consultants is very collaborative and work well together. If they were in a larger unit, each consultant would end up specialising in a limited number of procedures. As Dr Gupta explains, "*The skillset is often similar in all the procedures that we do. Ultimately, it's wire and catheter skills, balloons and stents, I don't think it's necessarily true that if you sub specialised then you would become the best at one thing.*" He goes on to say "*We foster that collaboration environment and we have a nice range of level of expertise, which offers different outlooks on intervention. Whenever we introduce a new procedure in this department, we always do it as a joint procedure, such as when we introduced fibroid embolisation in 2013, then TACE and PAE. Once you become more established and have a number of cases under your belt then you can go off by yourself and do the case independently.*"

Dr Gupta's typical day can go from doing a PTC or a nephrostomy to doing an angioplasty, an iliac stent, to doing a uterine fibroid and percutaneous liver ablation. His favourite procedure is PTC because it involves all the skillset that are used in IR: doing an exquisite ultrasound puncture in a tiny biliary duct, then a wire cannulation through the CBD and finally balloons and stents.

Dr Harding has a personal interest in embolisation, which is "*the real future of IR*" in his opinion. Since he joined the team 10 years ago, he started TACE, UAE and PAE services and began to do some vascular malformation work as well. While there isn't anything much new in nephrostomy or biliary drainage, he anticipates an important

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Growing IR/IO departments

change in the way some benign conditions like BPH, fibroids, osteoarthritis or rheumatoids are treated. The idea is that if the primary pathological sites can be embolised in a minimally invasive way, avoiding open or major surgery, it is possible to prolong the period where a patient does not have to have open surgery. The IR community is just beginning to look at treatment in the knee for osteoarthritis. At the moment the only treatment these patients have is analgesia and very often they take it for a long time. They may start getting stomach ulcers and bleeding, or they will take opiates and start developing an addiction. The advantage for embolisation would be in the younger patients who are not able to have a joint replacement or who want to prolong the period before they have a joint replacement.

Despite a heavy workload limiting his time spent on research, Dr Harding acted at the Principle Investigator at UHCW in one of the top five contributing centres in the national UKRoPE study, the first multi-centre research into PAE in the UK. He expects to increase the capacity for PAE with the opening of the new vascular lab; this lab will house a GE Innova IGS 5* which will complement their Discovery IGS 7 installed this year. "*The sky is the limit*" says Dr Harding of PAE, considering that approximately half of the men over the age of 55 years old have BPH. He thinks that the Discovery system is a "*game changer in technical delivery*" of such a complex and time-consuming procedure.

Transformation of the IR department

Dr Harding has been heavily involved in the transformation of the IR department and his vision is that the acute service would run in the Innova IGS 5 lab (floor mounted vascular room). The Innova IGS 5 will provide every state-of-the-art application such as 3DCT HD[1], also known as cone-beam CT, necessary for any emergency. This would make the Discovery IGS 7 lab, which is more spacious and allows better patient access, dedicated to slow, complex and thoughtful work such as PAE. At the moment, elective and acute cases are booked on the same list, which means that it is very difficult to concentrate on the long and difficult cases.

Along with increasing equipment capacity, Dr Harding emphasizes on building the skills up of the whole team to allow more complex work. He thinks GEHC has been key in delivering ad hoc applications and trained 5 radiographers as superusers, who are embracing the equipment. As they were accompanied by GEHC during their first live procedures, he has observed a "*major shift*" in enthusiasm and positive attitude towards undertaking the most complex cases. "*We were not quite sure how we were going to use all that new technology when we first started. It is necessary to have something that either makes your procedure better, quicker, and helps the patient either reducing the dose or reducing the procedure time or the contrast. The augmented guidance technologies that are enabled by the 3DCT HD[1] have made a big difference. As the operator, it changes how you feel about delivering the procedure because you know something rather than hope for it. When you know where the ostium is, you can put that coil in much more accurately. If you know that that is the supply to the tumour in the liver, you can embolise it more accurately rather than guessing. That shift has changed the quality of what we do.*"

Dr Gupta found that the most beneficial application was the CT fusion with fluoroscopy. He has done a few contrast-free iliac artery embolisations and found it "*phenomenal*". He says "*To have the confidence of knowing where your vascular anatomy is, particularly if we are doing an up-and-over approach, we know the tortuosity of the iliacs, we can drop the catheter without any contrast. If we know where the origin is, we can then put the coils in. On another two cases I have just put a tiny bit of contrast to give me the reassurance. I can predict I will do it routinely without contrast.*" Dr Gupta insists that it is "*invaluable*" to have dedicated IR radiographers in the department to operate the equipment and prepare 3D fusion models (see more details in Matt Curtis' interview p.14).

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* Innova IGS 5, configuration 540

"Liver ASSIST V.I.[2] is a game changer"

When asked about the main challenges for liver HCC treatment, Dr Harding replies with a smile "*the main challenge is to get enough patients!*" More seriously, it is about security of knowing what the blood supply to the tumour is. It is possible to get blood supply from so many different places (the phrenic arteries, the contralateral side of the liver, etc…).

"*Liver ASSIST V.I.[2] is a game changer. Before using it, we were trusting our best suspicion rather than a certainty. Using 3DCT HD[1] for TACE has given me much more confidence than fluoroscopic and angiographic imaging alone when treating TACE patients. It gives me the assurance as to where the tumour supply is, and precise anatomy which can be correlated quickly with the diagnostic pre-procedure CT imaging, meaning that the dose of chemotherapy to the tumour can be maximised and dose to local non-cancerous liver tissue minimised. This is definitively in patients' interests. The virtual injection adds considerably to the anatomical information, relatively quickly once the 3DCT HD[1] dataset is acquired, by giving the operator a clear feel as to where the optimal points of injection for the treatment are, again as an effort to maximise patient benefit and reduce collateral damage and complications. We will have to see in the future but I suspect use of this new technology will reduce the number of procedures patients have to undergo to achieve disease control.*"

"We have already reduced DSA with CT fusion for PAE"

At UHCW, the PAEs are performed as dual operator procedures, for safety and upskilling. Typically, one operator oversees one side while the other operator is always available for a second opinion. Dr Harding thinks the main challenge is not only the accurate delivery of embolic agents while protecting the bowel, the penis and the bladder, but also the procedure time. He reckons the quality outcome has always been good, but the patient radiation dose has been too high, mainly due to the high number of DSAs performed in the interest of being cautious and careful. The risks are greater of off-target embolisation when doing a PAE than they are with TACE or fibroid embolisation. To start answering the radiation dose concerns, Dr Harding has developed a new workflow using CT fusion with fluoroscopy at the beginning of the procedure. "*We have already reduced DSA with CT fusion. The 3D model from the CT is very informative and we should utilise that as much as possible in the future*". He draws the model of the prostatic arteries and their origin in the morning of the procedure and gives it to the radiographer who will segment a 3D model out of the pre op CT. This model will then be fused with live fluoroscopy. This way, the aortic bifurcation and the catheterisation of the internal iliac artery is done without any contrast, and the catherization of the prostatic arteries uses a minimal amount of DSAs. Inside the dominant prostatic artery, the operators perform a 3DCT HD[1] acquisition to find the anastomoses as a best practice. When asked for advice by other centres on how to develop a PAE practice, Dr Harding replies: "*You must have 3DCT HD[1] capabilities, get a proctor, take your time. We were very lucky that the Southampton team came to proctor us, we learned a lot from them in 1-2 visits they came. We went to Southampton once as well. If you have a small volume of PAE I would recommend to have two operators, as you can make mistakes very easily. This is why I do them together with my colleague Dr Dhillon. You have to remember it is elective, It is often patients who have actively chosen your treatment because they have considered their options carefully and really want the high-quality outcome. It is a high-level skill. You are in small vessels and if you make a mistake with the embolisation then you are going to cause the patient harm.*"

PAE procedure with CT fusion

Leg thrombolysis with a still table

Operating with a still table

As trainees, Dr Harding and Dr Gupta developed their practice on ceiling-mounted systems and are used to moving the table as little as possible. They explain that, for complex work, you cannot afford to let the wire move. If the whole table has to shift, the consultant and the nurse have to shift and it is very easy to lose the wire position. Also, when the table is moving, it usually means that the cables and the monitor must be moved too. Even for a PTC, Dr Gupta explains that the very fine puncture does not allow you to move the patient. As they think that the table should stay still, they were not sure that the Discovery IGS 7 could deliver a similar experience. Fortunately, after the learning curve phase of the equipment, "*we almost got rid of the moving table with the IGS 7*". They found their way to comfortably deliver everything they needed to. "*The room space and the non-moving table have been a key change. I can do retrograde right or left with the gantry at 90° and go all the way down the leg now without moving the table*" says Dr Harding. The physical room space is also taken into consideration:
"*The physical room space has made a difference because when we use a 300 cm wire, we need a large amount of space for the nurse to be at the end of it and get exchanges done. It needs to be quick enough so that the patient can stay on the table with just local anaesthetic.*"

Even after mastering most of the equipment, there is more to discover. Dr Gupta thinks that when the IGS 5 lab opens, he will have the capacity to explore the needle tracking software (Needle ASSIST[3]).

Dr Harding is excited about the future of interventional radiology and the myriad of potential emerging procedures, particularly in the joints. He suspects we could embolise the shoulder, the elbow, the hip ,etc… The amount of research that is needed in this clinical area is still significant but hopefully, the IR team at UHCW will soon have all the necessary resources to be part of this fascinating adventure.

Growing IR/IO departments

Matt Curtis is an advanced practitioner radiographer with a special interest in IR and MSK. He shares his time between reporting MSK plain films and being an active member of the Interventional team. He is convinced that the good collaboration between consultants and radiographers and the personal desire to improve one's radiographic knowledge are fundamental to improve patient outcomes.

How is your department organised?

Matt Curtis: *"We have a combination of fixed and rotational staff. Within the fixed staff there is the superintendent who looks after IR, theatres and other fluoroscopy examinations, and then the fluoro & IR lead with a team of four fixed senior radiographers.*

Rotational radiographers come once every four to five weeks. Operating a rotation is beneficial as this allows fixed staff to become clinical experts, advising in complex situations but at the same time, every radiographer should be encouraged to develop their own interest and explore the whole scope of radiographic skills."

What is an advanced practitioner?

Matt Curtis: *"Advanced clinical practitioners (ACPs) are healthcare professionals with the skills and knowledge to allow them to expand their scope of practice to better meet the needs of the people they care for. In practice, we do research, service development, and those clinical roles are not limited to one subspecialty: there are advanced practitioners in plain film, in CT and MRI and ultrasound (sonographers rather than advanced practitioners). The key feature in being an AP is to develop innovative practice and identify where service and quality improvements can be achieved to make radiographic practice better. In terms of plain film, radiographers, when suitably trained, can provide a radiographic diagnosis, leaving the most complex diagnoses to radiologists."*

What is your specialty as AP and how was your training?

Matt Curtis: *I spend half of my working week writing radiology reports on MSK plain films regardless of the referral source and the referring speciality. I applied for a training post like any normal job. Once I was accepted, I spent the next 2 years training to interpret and produce diagnostic reports on appendicular and axial MSK plain films. There are a multitude of other advanced practitioners specialising in other areas; locally we have advanced practitioners reporting CT head scans and interpreting barium or water-soluble swallows.*

How was the training in the Discovery IGS 7 lab?

Matt Curtis: *"I think the training was surprisingly easy. We had a good background already thanks to the previous GEHC Innova 4100. Some of the new functions like the additional gantry movements does not take a long time to learn.*

The augmented guidance and imaging protocols seem sophisticated when you first look at them but as soon as you do a couple, it becomes second nature. I am a strong believer that we are not just technicians who move a machine. We are specialist professionals who can contribute to the ease of the procedure and patient outcomes. IR at UHCW has prided itself on the working relationships between radiographers and radiologists whereby we facilitate what they desire but we can act as imaging advisors. We can anticipate what is going to happen next within a procedure and have already set up for that next step before the radiologist mentions it."

Do you regularly use the image fusion between CT or 3DCT HD[1] and fluoroscopy?

Matt Curtis: *"Yes. The application to generate 3D models is not difficult to learn. Regardless of their experience of CT or just pathology in general, every radiographer is able to produce the 3D model that can be used for fusion.*

For example, we can generate a highly accurate prostate artery 3D model from a CT for a PAE without any problem. For the liver, Liver ASSIST V.I.[2] is very easy to use with simplified steps. The only slightly complex aspect is the acquisition of the 3DCT HD[1] scan, how to set your room up, where all the nursing and the radiologist should be, so that the spin is not interfered with. Once you have the experience of setting the room up it is a smooth and repeatable process."

How do you set up the room for every procedure?

Matt Curtis: *"For anything that we would class as a straight tube (aortic interventions, prostate artery, liver, pelvic angiograms) we know where every member of the interventional team and where all the equipment should be positioned. That means that the table, the monitoring cables and the leads will not interfere with the 3DCT HD[1] spin.*

We also designed a process to undertake fistula interventions solely based on the movements of the tube without having to swing the table to visualise the whole arm. Previously, we used to have a large arching table to get the arm either vertical or horizontal across the imaging screen. Now, we can have a fixed table and we can then move the tube down the arm, across the patient and back into a central position."

Did you notice any difference with the radiation dose vs image quality?

Matt Curtis: *"We are not switching between low and normal dose setting as often as we used to, compared to our previous Innova 4100 lab. We are even imaging some larger patients on the lower dose setting without compromising the image quality whereas previously this was an issue. In a brief comparison between our new Discovery IGS 7 and our older Innova 4100 lab, on a low dose varicocele or fibroid protocol setting the dose was, on average, 6 times lower with the Discovery IGS 7, with comparable screening time. The high-quality treatment that we can deliver with the Discovery IGS 7 means that we are accepting patients from across the country for complex treatment and procedures. Personally, I have seen the best image quality of mesenteric angiograms and tiny segmental branch arteries with this system."*

1 3DCT HD is an option sold separately. Includes 3DXR. Requires AW workstation and Volume Viewer.

2 Liver ASSIST V.I. solution includes Hepatic VCAR and FlightPlan For Liver that can be used independently. It also requires an AW workstation with Volume Viewer and Volume Viewer Innova. These applications are sold separately.

3 Needle ASSIST solution includes TrackVision 2, stereo 3D and requires AW workstation with Volume Viewer, Volume Viewer Innova. These applications are sold separately.

The statements by GE's customers described here are based on their own opinions and on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist, i.e. hospital size, case mix, etc., there can be no guarantee that other customers will achieve the same results.

DOC2533098

Liver TACE using Liver ASSIST with Virtual Injection[1]

Courtesy of Dr James Harding, Consultant Interventional Radiologist at University Hospital Coventry & Warwickshire (UK)

Patient History

A 58 year old gentleman was initially diagnosed with chronic liver disease and cirrhosis 18 months ago when he presented to hospital with leg swelling and melaena. Since then he suffered a severe variceal haemorrhage 6 months ago which was treated successfully with variceal banding. He underwent a CT scan of his thorax, abdomen and pelvis on account of gradual weight loss and a raised alpha-fetoprotein. This demonstrated multifocal hepatocellular carcinoma.

MDT discussion deemed his disease unsuitable for resection or ablation within EASL criteria and he was therefore seen by a Hepatologist with a view to TACE (Trans Arterial Chemo-Embolisation) treatment. Following appropriate work up and patient consent, he attended our unit for treatment in August 2020, initially with a view to treating the right lobe predominant disease at the first visit, assess the response then, if well tolerated, progress to treating any residual disease.

Procedure

The procedure was undertaken from a right retrograde CFA puncture, 5F sheath. Initial cannulation of the coeliac shows the origin of the left hepatic artery. Large calibre replaced right hepatic artery from the SMA was clearly identified on direct cannulation and entered selectively.

On table 3DCT HD[2] angiogram (40°/sec with an injection of 24 mL, 3cc/s and 3s X-Ray delay) undertaken from proximal right hepatic artery confirmed two large hypervascular lesions in segment 8.

Liver ASSIST V.I.[1] was utilised to identify the main feed to these lesions with three likely feeds to the more lateral inferior lesion; all points of interest for injection carefully assessed via the workstation to maximise dose to the lesion and minimise collateral embolisation. Supply to the more lateral lesion was more challenging to cannulate selectively.

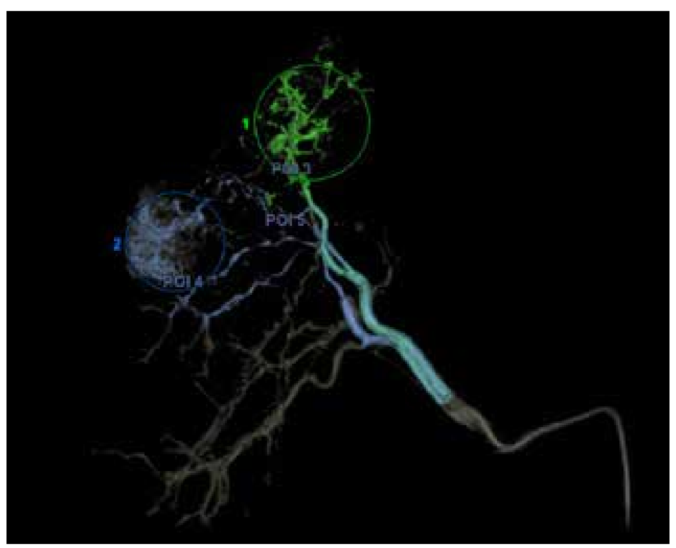

Fig 1. Liver ASSIST V.I.[1] shows a main feeder for the superior tumour (green) and 3 likely feeds to the lateral inferior lesion (blue).

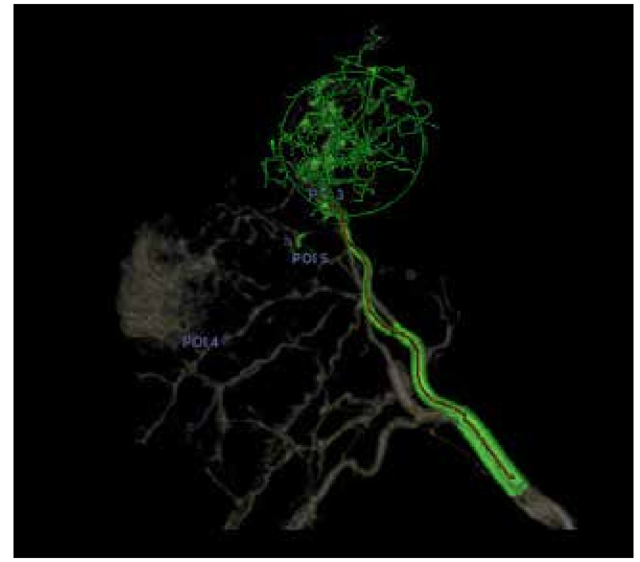

Fig 2. The virtual injection indicates that injecting at the level of "POI 3" will ensure maximum coverage of the superior tumour (green).

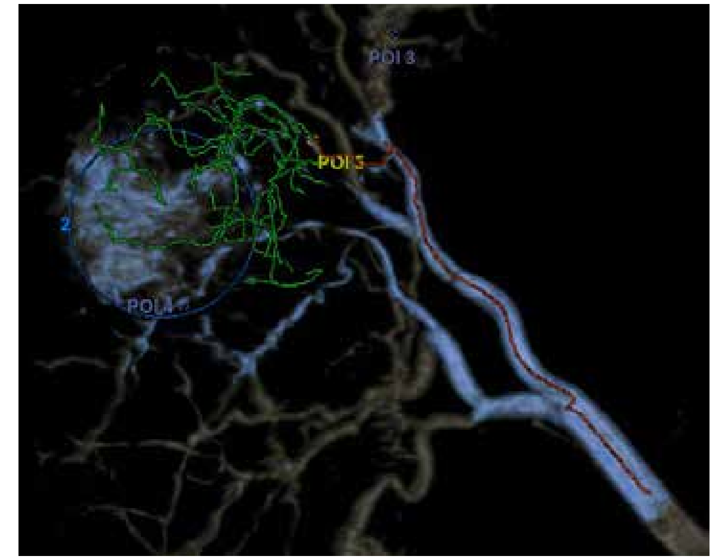

Fig 3. For the lateral inferior tumour (blue), "POI 4" and "POI 5" are pinned as embolisation targets.

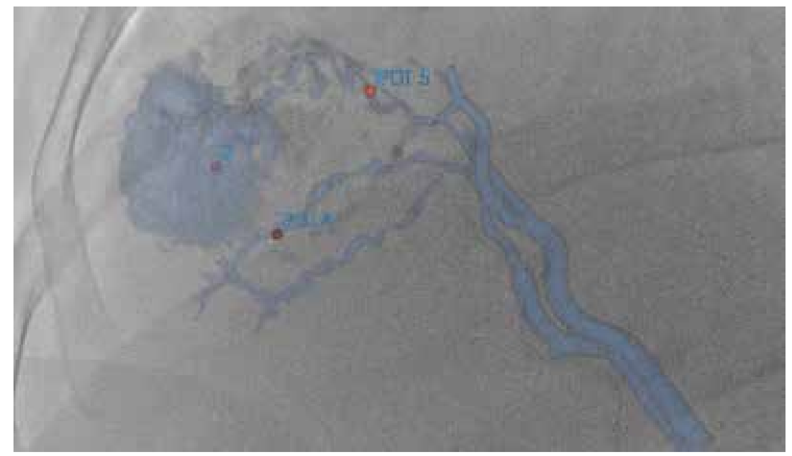

Fig 4. Embolisation of the main feed via "POI 5" using fusion of the planning with live fluoroscopy.

Initially, the inferior feeding branch was treated but this had to be done from a relatively proximal position - only a small volume of embolic beads was utilised.

Cannulation of the main feed was very difficult but ultimately achieved. From here, the remaining dose of embolic beads was administered.

The procedure was well tolerated requiring only light sedation and analgesia. The puncture site was closed straightforwardly with a closure device.

Patient Outcomes

The patient was well in the peri-procedure period and was discharged the following day with follow up CT imaging planned at 4 weeks post procedure. It was explained to the patient that he might need treatment on several occasions to achieve disease control.

Conclusion

"Liver ASSIST V.I.[1] makes the operator confident on where to deliver the embolic agent. It gives one the assurance as to where the tumour supply is, meaning that the dose of chemotherapy to the tumour can be maximised and dose to local non-cancerous liver tissue minimised. The virtual injection adds considerably to the anatomical information by giving the operator a clear feel as to the optimal point of injection for the treatment, again to maximise patient benefit and reduce collateral damage and complications. We will have to see in the future but I suspect use of this new technology will reduce the number of procedures patients have to undergo to achieve disease control due to the added accuracy it gives in what can be quite complex medical situations. This is definitively in patients' interests."

1 Liver ASSIST V.I. solution includes Hepatic VCAR and FlightPlan For Liver that can be used independently. It also requires an AW workstation with Volume Viewer and Volume Viewer Innova. These applications are sold separately.

2 3DCT HD is an option sold separately. Includes 3DXR. Requires AW workstation and Volume Viewer.

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Growing IR/IO departments

Overcoming the challenges linked to complex anatomy for IO procedures with Discovery IGS 7* and ASSIST solutions[1]

Known for its clinical excellence, Providence Little Company of Mary Medical Center Torrance, California, uses advanced technology and state-of-the-art medical techniques to provide comprehensive medical care for each patient.

In addition to excellent medical, surgical and critical care services, the hospital offers a number of specialty programs and services including advanced robotic surgery for gynecologic, urologic and cardiac procedures; a Heart Center that features advanced cardiac catheterization and open heart surgery; and state-of-the-art interventional and diagnostic radiology services.

* Discovery IGS 7, configuration 730

Growing IR/IO departments

Dr. Patel is Chief of Interventional Radiology at Providence Little Company of Mary Torrance and San Pedro Hospitals.

He graduated from the University of Pennsylvania obtaining a degree in Bioengineering. He then completed his MD at Harvard Medical School, and an internal medicine internship at Beth Israel Deaconess. Dr. Patel completed his Radiology residency and Vascular & Interventional Fellowship at the University of California at San Francisco. His interests lie in interventional oncology, peripheral arterial disease, venous disease, as well as advanced cross-sectional imaging, including CT, MRI, and PET.

Dr. Patel aims to stay on the forefront of medical innovations and is currently a Research Associate of Radiology at UCSF. He is a former CEO/Co-Founder of an NIH/National Cancer Institute funded med device startup for safer cost-effective liver cancer treatment. Dr. Patel works with several startups, med tech companies, and universities to help create new technologies in medical devices and artificial intelligence.

As Chief of Interventional Radiology, Dr. Patel and his team have developed the interventional radiology/oncology practice at Providence Little Company of Mary into a high-level center.

Growing the IR/IO program using Diagnostic Imaging to connect with referring physicians

Dr. Patel: *"Interventional oncology has been a growing field over the last decade, and during my training at Harvard and UCSF I heavily focused on oncology.*

There only are a couple major hospitals in our part of the Los Angeles metropolitan area. Providence Little Company of Mary quickly realized that developing an Interventional Oncology program locally in order to avoid sending patients to distant tertiary centers was the best strategic approach. That's what really enticed me and excited me to start the IO program here.

Currently, we provide a complete IR/IO service line ranging from basic services, such as long term central venous access, to the more advanced procedures like visceral/tumor embolization (Y90, TACE), ablation, spine procedures, and GI/GU interventions.

One of the things that has really helped me build this practice is performing a wide range of IR procedures. They get our name out there and help build up our reputation to get the advanced procedures.

On top of that, our IR doctors pride themselves in being able to read CT, MRI, Nuclear Medicine, and PET. We have the ability to call up the oncologist and say – here's not only the diagnosis on the MRI, but I can also offer you different kinds of treatment like chemoembolization, Yttrium-90 or ablation.

This way we are more like a conventional surgeon or treating physician because we can do the follow-up. The referring physicians see the value that our interventional radiology team provides by not only making the diagnosis on imaging, but also suggesting treatment options, many of which we can perform.

This paradigm and collaboration between diagnostic and interventional radiology skillsets and colleagues really helps solidify and build a referral base.

In terms of IO services offered, currently we are doing almost every type of embolization available in the oncology space, ranging from bland embolization, cTACE, DEB-TACE, and Y90. We also perform percutaneous ablations with CT and ultrasound guidance as well predominantly for kidney and liver tumors and have a growing spine tumor ablation practice. We also aim to expand our practice to lung nodule ablation."

The unique value of IO as a localized and selective therapy and expanding treatment options to other organs

Dr. Patel: *"In IO, one of the main things that we are going to start seeing is multi combination therapy, being able to combine immunotherapy with embolization and having one affect the other ideally in synergy. There are a lot of studies trying to demonstrate that an embolization or ablation on a tumor could release tumor antigens driving the immune system to combat the tumor in conjunction with immunotherapy drugs. This would lead to abscopal systemic effects where disease would respond outside the immediate treatment zone.*

There also are a lot of new oncologic targeted receptor therapies out there, and it would make natural sense for us to think about intra-arterial delivery of those therapies or combining them with embolization. That is what we

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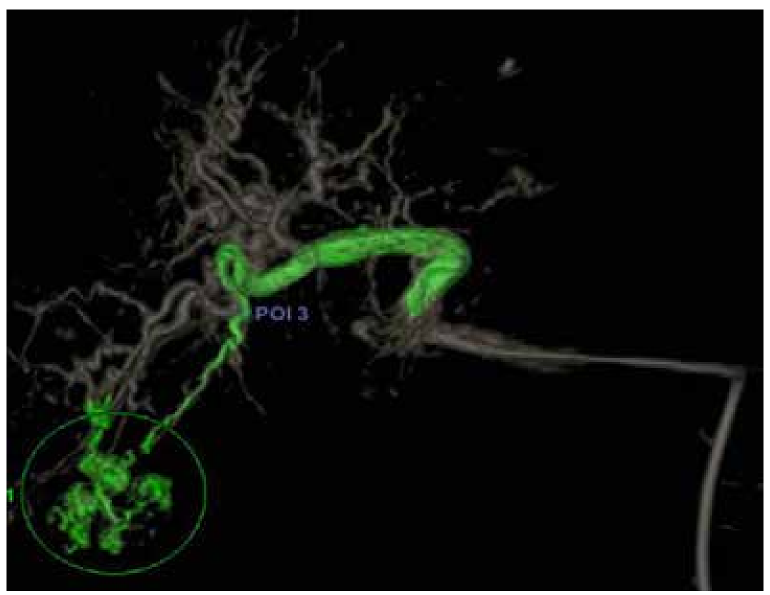
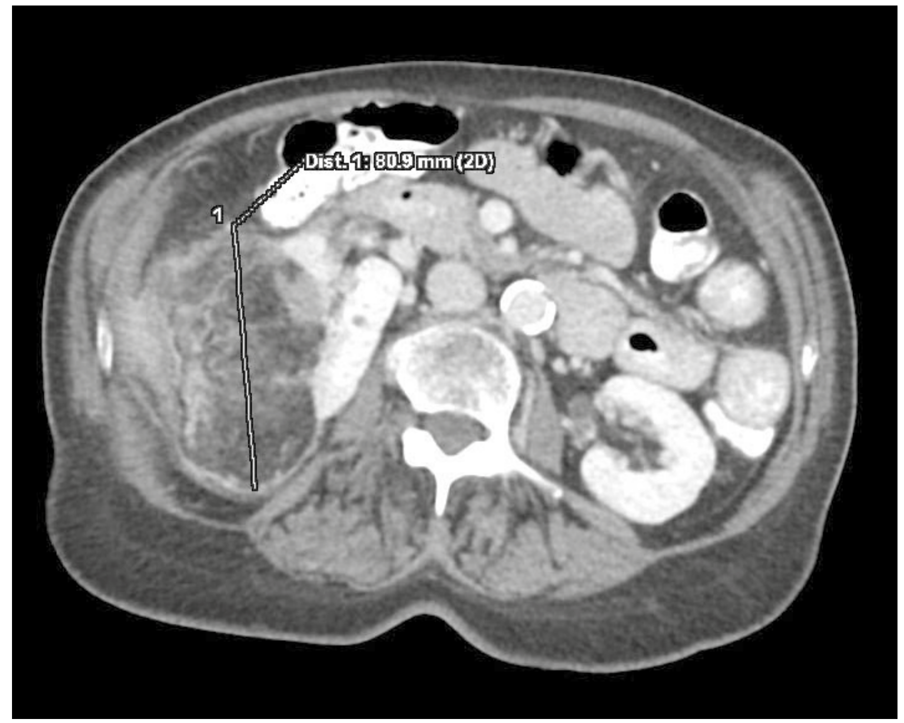
often see in cancer. It is not a single therapeutical approach that cures the patient, but rather a combination of approaches that can make each one less toxic but more effective.

In IO, it would behoove us to assist in treatments of cancers that affect the population at a large epidemiologic scale like lung cancer, prostate cancer, breast cancer and colon cancer. The big value of Interventional Oncology is in localized therapy and delivering a targeted and super-selective treatment. Thus, another growth opportunity in IO may be the expansion of embolotherapy to other organs like the kidney and the lung,



and there is currently early data surrounding some of those techniques. Moreover, prostate artery embolization for benign causes has gained traction, but now there are some studies assessing its value for prostate cancers as well.

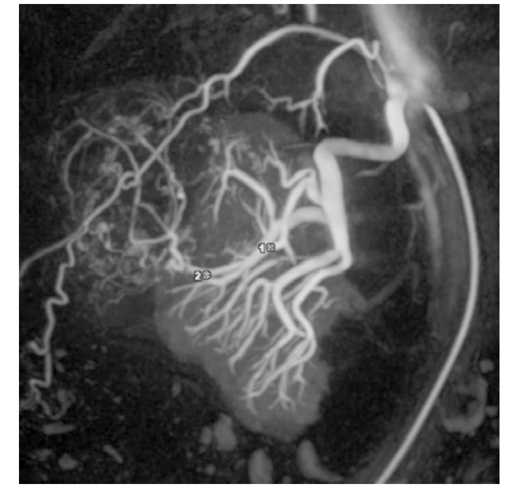
In order to confidently explore these exciting new venues in IO it becomes essential to get state of the art technology with better cone beam CT and advanced navigation tools because the anatomy of these organs like the prostatic arteries and bronchial arteries are very small and difficult to catheterize. Thankfully, both catheter and angio suite technologies have significantly progressed allowing us to explore more advanced IO treatments in more organs."



The specific challenges of the kidney

Dr. Patel: *"Arising within the kidney there is a unique benign tumor called an angiomyolipoma (AML). This tumor basically has 3 components, a conglomeration of tissues made of blood vessels, muscles and fat, all benign but which in some cases grow to a critical size where the blood vessels could rupture and lead to life-threatening spontaneous internal hemorrhage.*

When detected (usually incidentally) on CT, MRI, or ultrasound, if they are over 4 cm in size they warrant prophylactic treatment, most commonly with bland embolization. Sometimes if undetected, patients unfortunately arrive in the emergency room with a life-threatening hemorrhage.



Because this is a benign etiology, the urology surgeons tend to favor a minimally invasive IR approach over formal surgery, which would include at least a partial nephrectomy. The endovascular treatment allows for more nephron sparing that is, sparing more tissue compared to a partial nephrectomy and because there is a big vascular component in the angiomyolipoma that typically means arterial embolization can be successful.

Often one of the biggest challenges with kidney embolization is that the kidney's anatomic structure can often make renal angiography difficult to interpret. Of course, it's a highly vascularized organ, but the kidney has a very thin anterior to posterior diameter. It is almost like a pancake structure as opposed to the liver which is a very wide structure. Thus, when interpreting renal angiography there are numerous parenchymal arteries superimposed in layers on a relatively thin structure in AP dimension. As a result, it can be difficult to distinguish

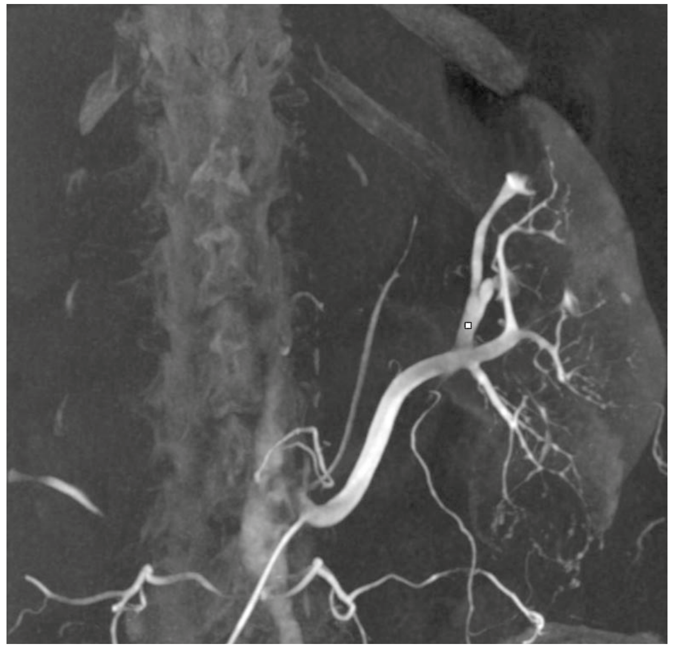
...

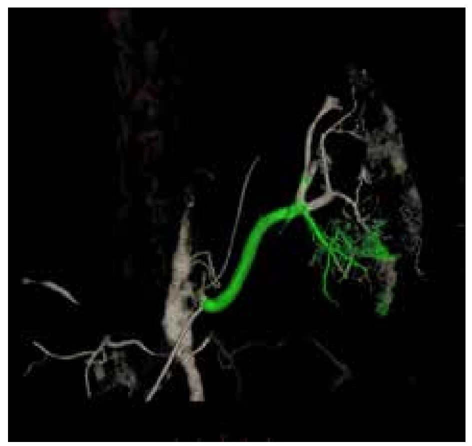
the location of one vessel with regards to another vessel in the AP dimension. In the liver, it is generally easier because lateral beam angulation will allow you to separate the hepatic artery branches. In the kidney, however, finding the correct beam angulation is often challenging and an ad hoc process, which means we are obtaining more contrast images. This leads to more fluoro time and longer challenging cases with complex small arterial anatomy.

The other challenge with renal angiography is the fact that the kidney is excreting contrast, so while it is necessary to perform contrast angiography, it also leads to corruptions of images as the renal pelvis pools with contrast."

Standardizing the use of 3DCT HD[2]

Dr. Patel: *"To overcome these challenges, my current approach is to acquire a high quality cone beam CT as soon as I catheterize the main renal artery, and minimize any prior contrast administration until that point. I then use the CBCT to accurately assess the vascular anatomy of the kidney and set my game plan by getting a good roadmap of the whole anatomy before the kidney is contaminated with too much contrast. In my experience, CBCT for renal tumor embolization has significantly reduced procedure time, complexity, fluoro time and contrast administration, because we spend less time trying to separate structures by doing different obliques with images confounded by contrast excretion, and inevitably getting into the wrong artery.*





Angiomyolipomas specifically are challenging because there are often multiple feeding arteries involved. We are already working with a challenging organ, but now we must also find all the feeders to the tumor, so again the CBCT is very helpful at the beginning of the case.

In that sense, having access to a state of the art angio system like the Discovery IGS 7 is critical because it becomes mandatory to get high quality CBCT with good spatial resolution to help collect as much detailed information as possible.

I think that the ASSIST solutions[1] that comes with the 3DCT HD[2] has been very beneficial in the kidney in the sense that I am not only getting the raw CBCT data (which ends up being a stack of 300 to 400 images) but it is also very helpful in extracting the most relevant information out of the CBCT and helping confirm my game plan, while ensuring you are not missing any other feeding vessel. As a result, of course you are going to get a safer, faster and more effective treatment.

A typical angiomyolipoma procedure with the Discovery and the ASSIST solutions[1] will take me around 1-2 hours. In the past, when I was only relying on fluoroscopy and DSA, I would say a minimum of 2-3 hours per case."

The predicted value of Embo ASSIST[3] for AML and other embolization procedures

"I do believe that Embo ASSIST[3], which has just been released, would be extremely useful on AML embolization cases both for tenured and less experienced Interventional Radiologists. As an example, even though I do about 10-15 AML cases a year, I had a case recently where I had to scroll multiple times through the raw CBCT data in order to assess 4 different vessels that could potentially feed the AML. Had I had Embo ASSIST[3], it would have been much easier and faster to virtually interrogate those vessels and determine if they need to be embolized or not which would save me a lot of time. I do think that, even though I'd still manually overlook the results am getting from the software (at least initially), it would give me more confidence that I am not missing a vessel and that am correctly treating the lesion.

This could also be an extremely valuable tool to train fellows and get them more comfortable extracting the pertinent information out of the CBCT acquisition during their training years. Not only do I see value for it in the specific AML set up, I also think it could help accelerate the use of CBCT in several IR procedures. As an example on GI bleed settings, because we currently lack tools like this, I sometimes avoid doing a CBCT because it is an emergency case where the patient is bleeding and acquiring a CBCT takes more time but a software like Embo ASSIST[3] could potentially allow to extract the relevant information off the CBCT acquisition in a more timely fashion, which would be a big reason to perform more CBCT in the Interventional Radiology practice."

Simulation of catheter tip (red) and territories affected by embolization (green).

The statements by GE's customers described here are based on their own opinions and on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist, i.e. hospital size, case mix, etc., there can be no guarantee that other customers will achieve the same results.

1 ASSIST solutions are composed of multiple medical devices. For more information, please refer to GEHC's website. www.gehealthcare.com/assist

2 3DCT HD is an option sold separately. Includes 3DXR. Requires AW workstation and Volume Viewer.

3 Embo ASSIST solution includes FlightPlan For Embolization, Vision 2, VesselIQ Xpress, Autobone Xpress and requires AW workstation with Volume Viewer, Volume Viewer Innova. These applications are sold separately. May not be available in all markets. Refer to your sales representative.

Growing IR/IO departments

A new Interventional Radiology and Oncology setup for the Paris Hospital Group

Tenon Hospital, Sorbonne University, Paris, France.

Following the installation of a new interventional suite equipped with a Discovery CT scanner, an OEC Elite CFD C-arm and a LOGIQ™ E10[1] ultrasound, in addition to the existing Innova IGS 5* angio room, Professor François Cornelis (Tenon, AP-HP) describes his methods and techniques in interventional radiology at Tenon hospital.

*Innova IGS 5, configuration 540

Professor François Cornelis, MD, Ph.D., FCIRSE is leading the Interventional Oncology Department at Tenon Hospital, Sorbonne University, Paris, France.
He is specialized in cancer treatment, in particular pain palliation and he performs all types of image guided endovascular and percutaneous ablation procedures.

Tenon Hospital covers diverse activities for the group (Tenon, Saint-Antoine and Pitié-Salpêtrière) such as interventional oncology (vertebroplasty, cementoplasty, bone ablation, tumour ablation and pain treatment), interventional vascular radiology (urology, nephrology, hepatogastrology, gynaecology and pneumology), along with permanent and emergency haemorrhage assistance.

These activities are divided between the Innova IGS 5 angiographic system and a new theatre accommodating a Discovery CT scanner and the OEC Elite CFD mobile C-arm.

Vascular interventions (embolization, TIPS...), osteosynthesis and hepatic procedures are all performed on the Innova IGS 5 using 3DCT HD[2]. Biopsy and vertebroplasty activities are transferred to the Discovery CT.

"*This opportunity to use two theatres allows us to optimise our planning by dividing procedures upfront, thus making it easier to receive emergency haemorrhage cases in the IGS room*" says Professor Cornelis.

Imaging systems and procedures

Several equipment strategies are possible when addressing such a vast range of procedures and anatomies. The Innova IGS 5 is equipped with advanced software that can integrate with another imaging system such as ultrasound. An optimal combination of these tools facilitates greater precision, better standardisation, and therefore better efficiency.

"*We use the Innova IGS 5 system for vascular procedures, such as prostatic, hepatic or renal embolisation. It is also used for procedures requiring needle guidance in cases where the contrast resolution of the CBCT is sufficient, such as when dealing with bone procedures. Another benefit lies in the ergonomic design of the Innova IGS 5 which is better adapted to large patients, compared with CT*", explains Professor Cornelis.

Nevertheless, some biopsies must be performed under CT guidance: "*The installation of the Discovery CT in a safe endoscopy environment, with access to the recovery room, allows us to perform complex biopsies such as pulmonary cases, particularly when ultrasound imaging is difficult. The set-up is completed with the OEC Elite CFD C-arm which enables us to perform percutaneous procedures, such as cervical vertebroplasties*", continues François Cornelis.

The role of CBCT in practice in the Innova IGS room

In the case of hepatic, renal or prostatic procedures, the 3DCT HD[2] provides three-dimensional visualisation which is important in challenging anatomical configurations. With Embo ASSIST[3], it is possible to define the embolisation strategy thanks to the virtual injection technology, which allows a simulation of the embolic agent pathway and accurate identification of the feeders to the zone requiring treatment.

According to Professor Cornelis, "*an extremely interesting aspect of such an augmented navigation software is the ability to view on the large display monitor the previously identified feeders, overlaid on the fluoroscopy in every working angle. This simulation and guidance make it possible to carry out procedures as quickly as possible. For percutaneous procedures, the main advantages are the comfort provided by the ergonomics of the system and the needle guidance software (Needle ASSIST[4]) which allows precise positioning and assessment of the needle position throughout the procedure*".

Benefits of the new LOGIQ™ E10[1] ultrasound

Nowadays the ultrasound imaging equipment must be as sophisticated as the diagnostic equipment, and must guarantee equivalent high-quality imaging. This is why the new LOGIQ™ E10[1] ultrasound is available in both rooms.

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Fig 1. CT/fluoroscopy fusion guidance for PAE with Embo ASSIST[3].

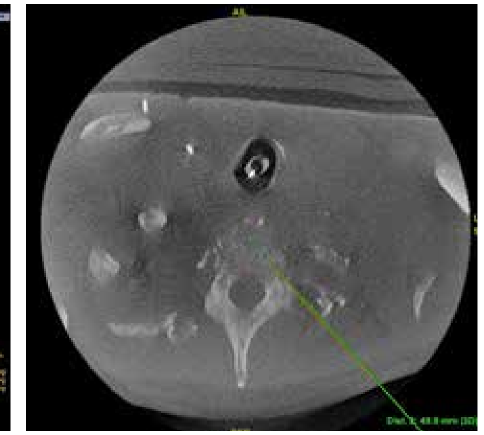

Fig 2. RF ablation using Needle ASSIST[4] (red: planned needle trajectory; green: current position of the needle computed from two fluoroscopic views)

The positive impact of the ergonomy of the Innova IGS 5 in the performance of procedures, according to Professor Cornelis

Thanks to the IGS geometry, all CBCT acquisitions are made from the top of the table which means that procedures can be standardised, particularly in the positioning of equipment and anaesthetic teams.

The position at the head causes no difficulty because, unlike others manufacturers, the Innova IGS system has an offset C-arm, allowing the patient's anatomy to be covered down to mid-thigh, without the need to move the C-arm to 90 degrees. Therefore, the pelvic region can be reached without difficulty. Furthermore, if the operator wishes to reach lower down for a CBCT acquisition, the patient's head-foot position can be reversed. Both patient positions allow an easy access to radial or humeral punctures.

In summary, the positioning of patients is simply standardised according to the type of procedure, the anatomy to be covered and the operator's working habits. In my case, I work systematically from the same side of the system, regardless of the type of intervention. This allows me to simplify the procedures particularly in terms of radiation protection.

Fig 3. Discovery CT and the OEC Elite CFD C-arm.

"*For example, a hepatic nodule can be clearly detected with a high-quality ultrasound, but more difficult to differentiate in the angio room with smaller secondary ultrasound equipment. Using this full-blown radiology equipment, we can now produce contrasted ultrasound, elastography and fusion imaging*", explains Professor Cornelis.

Furthermore, the LOGIQ™ E10[1] facilitates automatic fusion between CBCT and ultrasound. Thanks to the integration with the IGS, the precision of movement and safety of procedures have been improved. "*Until now, we have relied on cognitive fusion, meaning we overlaid the echography on the CBCT in our brain. Automatic fusion with INTERACT Active Tracker[5] greatly improves the workflow*", he adds. With more manual steps, it is also possible to fuse the ultrasound with pre procedural imaging such as CT or MRI.

Integrated Angiography – Computed Tomography suite?

The combination of a CT scanner and a fixed angiographic system that share the same patient table in the same room is still rare. It is particularly interesting for large traumatology centres, when handling emergencies. It allows a trauma patient to be placed directly onto the scanner platform for immediate imaging and, potentially, to start the intervention right away.

"*If we consider the perspective of ergonomics and scheduling, in regrouping everything within the same room (CT, CBCT and ultrasound), the integrated Angiography-CT suite eases the flow of daily activities for very large teams, with lots of equipment, or for small teams with limited space.*"

Finally, in combined hepatic procedures, the integrated Angiography-CT suite makes it possible to enjoy the benefits of both angiographies and CT-guided ablations. "*Nonetheless, such usage remains a niche for specialised teams with considerable oncology expertise. Therefore, a careful analysis of clinical needs is advised before investing in an integrated Angiography-CT suite*", believes François Cornelis.

Interventional CT plus mobile C-arm versus integrated Angiography-CT suite

"*Within our hospital group, our strategy has been to equip our centre with the Discovery CT to conduct our CT procedures safely and efficiently. In practice, this mostly concerns biopsies, as we do a big volume of oncology. A room with an interventional CT allows us to free the diagnostic CT and therefore increase our volume of patients*".

"*Moreover, we added the OEC Elite CFD C-arm which allows us to perform vertebroplasties. The C-arm adds the spatial and temporal information that was missing with the CT alone for the safe injection of cement and to avoid leaks. We also plan to perform biliary drainage procedures and simple (varicocele) embolisations, which were previously carried out on the IGS 5 system. Ultimately, this setting is very close to the centralised model of the integrated Angiography-CT suite without the constraints and the cost*", concludes François Cornelis.

The statements by GE's customers described here are based on their own opinions and on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist, i.e. hospital size, case mix, etc., there can be no guarantee that other customers will achieve the same results.

1 LOGIQ is trademark of General Electric Company.

2 3DCT HD is an option sold separately. Includes 3DXR. Requires AW workstation and Volume Viewer.

3 Embo ASSIST solution includes FlightPlan For Embolization, Vision 2, VesselIQ Xpress, Autobone Xpress and requires AW workstation with Volume Viewer, Volume Viewer Innova. These applications are sold separately. May not be available in all markets. Refer to your sales representative.

4 Needle ASSIST solution includes TrackVision 2, stereo 3D and requires AW workstation with Volume Viewer, Volume Viewer Innova. These applications are sold separately.*

5 INTERACT Active Tracker is an optional feature of 3DXR (part of GE Interventional systems Innova IGS 5, Innova IGS 6 and Discovery IGS 7 or Discovery IGS 7OR). This feature supports only one 'Active Tracker' type: the OmniTRAX™ Active Patient Tracker of CIVCO™. 3DXR and INTERACT Active Tracker may not be available in all markets. Refer to your sales representative.

DOC2554155

Microwave ablation of a liver tumour using fusion between ultrasound and Cone Beam CT

Courtesy of Pr François Cornelis, Tenon Hospital Paris (France)

Patient history

A 79-year-old patient, operated in 2011 for a right hepatectomy after arterial and portal embolisation, came for treatment of a 10cm hepato-cellular carcinoma developed in a liver with chronic fibrosing hepatopathy caused by steatohepatitis in the context of a metabolic syndrome.
The MRI carried out in December 2020 shows a 2cm, subcapsular intrahepatic lesion of segment II in contact with the left hepatic vein, which has all the characteristics of a tumour with early contrast uptake at arterial phase, wash out at portal phase and hyper T2.

The medical history also includes:

- non-insulin-dependent diabetes treated with Metformin, Janumet and Repaglinide,
- arterial hypertension at 16mm that was left untreated,
- overweight (BMI 30)

We decided in MDT to treat the nodule percutaneously. The patient accepted the principles and the procedure was performed under general anesthesia.

Plan

On the available imaging review (CT and MRI, Fig 1), this lesion is visible on the CT scan but it could be more easily visible after portal injection. Once the patient was on the IGS table, we centered the CBCT acquisition on the liver with an acquisition delayed by 70 sec after injection of 80 cc of intravenous contrast. The nodule was visible on the CBCT (Fig 2). A tracker was positioned on the patient skin during the CBCT, sharing its coordinates with the LOGIQ™ E10[1] ultrasound without the need to be visible on every projection of the CBCT acquisition.

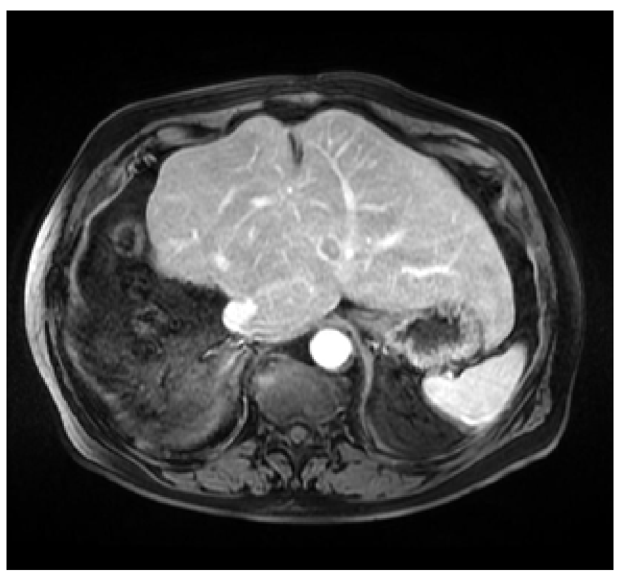

Fig 1. Pre-op MRI imaging.

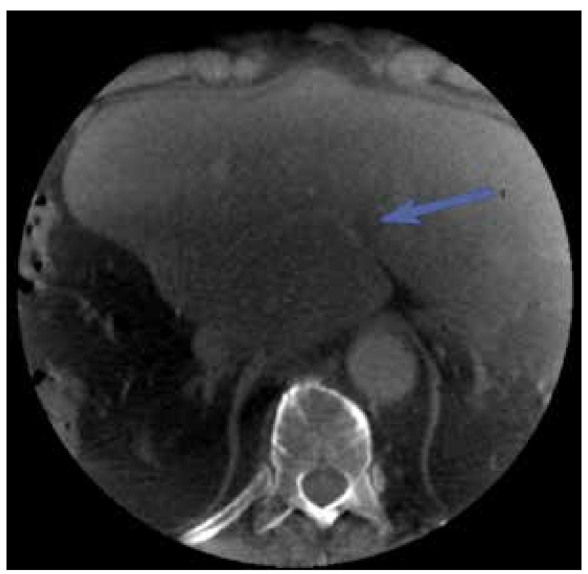

Fig 2. Identification of the lesion on the CBCT (70 sec delay and 80cc of contrast media).

Fig 3. Example of CBCT/ultrasound fusion with automatic registration.

Fig 4. Identification of the nodule using CBCT/ultrasound fusion.

Fig 5. Positioning of the needle using CBCT/ ultrasound fusion.

Guide

Thanks to INTERACT Active Tracker[2], the fusion between ultrasound imaging and CBCT is done with automatic registration (Fig 3). This fusion allowed us to identify the contacts between the nodule and the vascular and biliary structures (Fig 4). For example, on the ultrasound, the nodule was near a steatosis patch obscuring the image while it was clearly visible on the CBCT. We were therefore able to position the needle in the nodule without touching these structures (Fig 5). A CBCT was performed to confirm the position of the needle.

The treatment was completed after 7 minutes of ablation at a power of 65W in microwaves with a visualization of the ablation zone corresponding perfectly to the margins.

Assess

Post ablation assessment was performed under ultrasound with contrast media injection. The ablation zone was satisfactory. The patient woke up without immediate complications. Although we have to wait for the confirmation from post operative imaging, the fusion between CBCT and ultrasound provided more confidence by showing us the nodule during the treatment. Thanks to this technique, we can standardize the procedure and increase its safety, which was ultimately our goal.

1 LOGIQ is trademark of General Electric Company.

2 INTERACT Active Tracker is an optional feature of 3DXR (part of GE Interventional systems Innova IGS 5, Innova IGS 6 and Discovery IGS 7 or Discovery IGS 7OR). This feature supports only one 'Active Tracker' type: the OmniTRAX™ Active Patient Tracker of CIVCO™. 3DXR and INTERACT Active Tracker may not be available in all markets. Refer to your sales representative.

DOC2554163

Neurosurgery

Stress-free practice in a hybrid operating room: my view as a neurosurgeon

by Dr Ohbayashi, neurosurgeon at Matsue Hospital, Japan

Our hospital was founded in 1936 and is in the center of Matsue, the capital city of Shimane Prefecture in Southwest Japan. Thanks to our 598 beds, we fill multiple functions such as the designated regional support hospital, critical care center, tertiary care center, cancer treatment cooperation base and a disaster base hospital.

Our new operating room Discovery IGS 7 OR installed in April 2018 has proven to be a true hybrid theatre. Not only it is used by the Cardiology team for open heart surgeries, stent graft implantations into large vessels and transcatheter aortic valve replacements, but our Neurosurgery team also participate with direct surgeries and cerebrovascular surgeries. We find that the Discovery IGS 7 OR supports our operations very effectively. In this paper, we discuss mainly from the open surgery perspective about a surgery case in the hybrid operating room at our hospital along with the advantages of the Discovery IGS 7 OR.

Our hybrid operating room

Dr Ohbayashi
Neurosurgeon

Dr Ohbayashi graduated in 1991 from Hiroshima University and he was appointed Chief of the Neurosurgery Department at the Japanese Red Cross Society Matsue Hospital in 2009. He has a special interest in interventional neuroradiology and intraoperative CBCT.

With the intention to secure sufficient room to be certified as a TAVR approved facility, our largest operating room of 62 m^2 has been converted into the hybrid operating room. A single plane angiography system was selected in consideration of the installation space and budget.

Many surgeries that do not require angiography equipment are also performed in this hybrid operating room, and the essential functional needs as an operating room should be met regardless of whether equipped with the C-arm. During the selection, considerations we made included the layout of ceiling suspensions, efficient flow of operating room staff and hygiene. After a thorough exploration between the ceiling-mounted type and the mobile floor type, we decided to introduce the latter type of GEHC's Discovery IGS 7 OR.

Fig 1. Highly hygiene operating room without any obstructions under the high efficiency particulate air

The Discovery IGS 7 OR 's compact C-arm can create a comfortable unobstructed space as it moves to the corner (Figure 1) even though the room is fully equipped with many devices, such as pump oxygenator, anesthetics, ultrasound devices, and others.

The Discovery IGS 7 OR has an extremely unique mobile structure that travels predefined paths on the floor and allows the C-arm to be engaged or moved aside as required. The C-arm moves more smoothly compared to ceiling mounted C-arms. Also, surgeries can be performed in the highest quality hygiene environment because the air laminar flow from the high efficiency particulate air (HEPA) filters (Figure 1) is not blocked by ceiling rails and no bacteria are falling off from them.

From the planning stage of the HOR, we reviewed the surgical procedures, equipment operation, workflows of medical staff, and designed the power and gas supplies via the ceiling and wall surfaces We took into account the flows of the various devices in and out of the room. so that the floor was clear from unnecessary cabling and piping.

Neurosurgery

THE WORKFLOW OF OPEN BRAIN SURGERY

Step 1
General anesthesia

After bringing the patient into the operating room, general anesthesia is administered on the operating table (Maquet Magnus OR Table system) rotated 90 degrees, considering the location of the anesthesia machine during surgery (Figure 2).

Fig 2. General anesthesia

Step 2
Attaching the clamp to fix the patient's head

After the patient is fully anesthetized, the operating table is returned to its normal position and a carbon fixing clamp (DORO's product[1]) is attached to the head (Figure 3).

Fig 3. Attaching the clamp to fix the head

Next, set up monitoring systems, including the intraoperation navigation system (Medtronic Japan's Stealth Station), SEP, and MEP. There, the C-arm does not get in the way, even though these staff are busy moving around in the room (Figure 4).

Fig 4. Ample space secured for effective work

Step 3
Anti-collision check between C-arm and patient

After the patient and peripheral devices have been set up, we engage the C-arm to check for interference with the operating table (Figure 5). A short guided workflow helps us defining a virtual safe space around the head where the C-arm is not allowed to enter. This extra step is extremely important for smooth operation of the C-arm during a surgery, as it assures us confidence in safety during the surgery.

Fig 5. Dr Ohbayashi maneuvering the C-arm to engage

Step 4
Starting the surgery

The surgery starts. The equipment and tables required for operation are comfortably set up in the room (Figure 6).

Fig 6. : A scene from an operation

After craniotomy, set the microscope and continue the operation (Figure 7).

Fig 7. : An operation scene using the microscope

Step 5 Intraoperative angiography

The case will be outlined further down. First, we place the temporary clip to mark the location considered to be the shunt of the pial AVF. Then, we engage the C-arm after moving away the surgical instruments table and the microscope (Figure 8).

Fig 8. Engage the C-arm. Easy to engage with just keeping the drape in mind.

It only takes two minutes approximately to engage the C-arm after moving away the surgical equipment.
Thanks to the angiography, we confirm the location of shunt (Figure 9).

Fig 9. A scene of angiography scan during the operation

Step 6 Step 6 Resuming the surgical operation and final angiography

The C-arm was parked away (Figure 10) and we treated several feeders flowing into the veins.

Fig 10. The C-arm in parking position

After the procedure, the C-arm was used again for final confirmation, and angiography confirmed that the pial AVF was resolved.(Figure 11).

At the end, we closed the wound and woke the patient (Figure 12).

As described above, the C-arm is repeatedly used as much as required during the operation. It does not take much time to engage and disengage as it moves so swiftly. The peripheral tables for microscope and surgical instruments need to be slightly moved off each time, but the C-arm is so compact that surgeons and operating room staff feel much less stress in the environment where no anesthesia or surgical equipment come to interfere.

Fig 11. Perform intraoperative angiography again for final confirmation

Fig 12. The patient is awakened from general anesthesia

The case description

A male in his 30s. No special notes in his medical record nor in his family medical record. When he tried to get up from his chair after dinner, he had a weakness in his lower right limb. He was transported by ambulance because he became immobile on the spot. At the time of admission to the hospital, he had clear consciousness and had right hemiparesis (MMT: right upper limb 4/5, right lower limb 1/5). Head CT and MRI revealed subcortical hemorrhage in the left frontal lobe (precentral gyrus) (Figure 13).

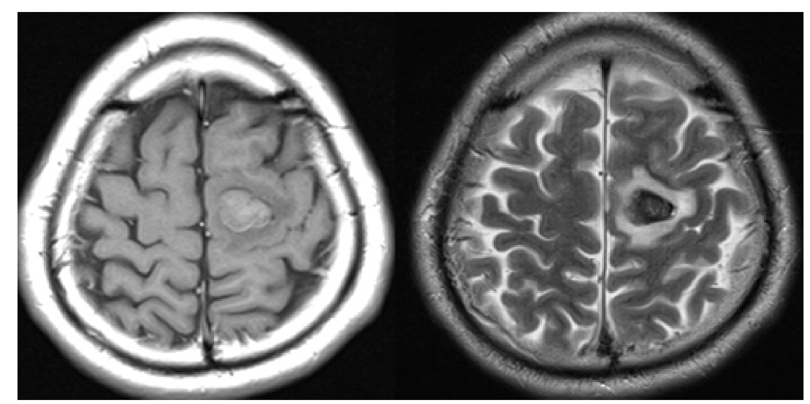

Fig 13. Preoperative T1-MRI, T2-MRI

Cerebral angiography confirmed an arteriovenous shunt that flows directly from the left anterior cerebral artery (posterior internal frontal A) via the superficial cerebral vein to the superior sagittal sinus without going through the nidus (Figure 14). The case was diagnosed as cerebral hemorrhage caused by pial AVF (arteriovenous fistula) and craniotomy was performed.

It was an eloquent area, and there were no abnormal blood vessels on the brain surface, and it seemed to be buried in a sulcus. Neuro navigators and SEP/MEP confirmed the motor area, and when exfoliated from the sulcus, we confirmed a venous pouch that changed to a red vein diverging from a normal vein, and the many arterioles flowing into it (Figure 15).

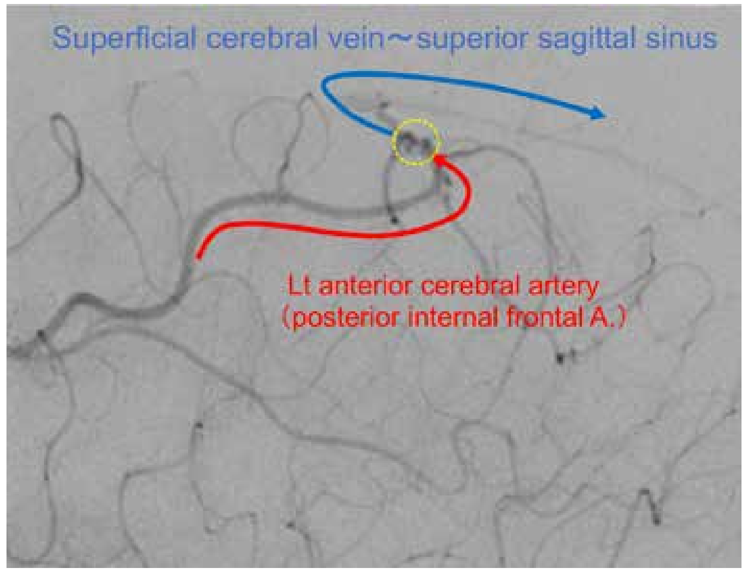

Fig 14. Angioarchitecture of pial AVF

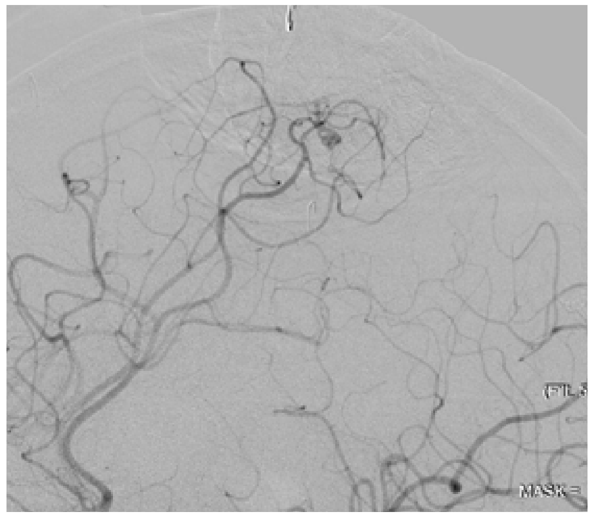

Fig 15-1. Preoperative DSA

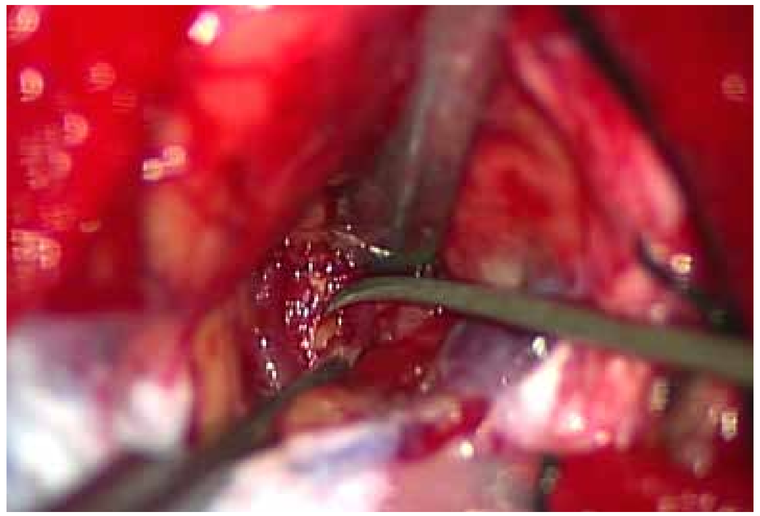

Fig 15-2. Intraoperative photo

Further into the procedure, intraoperative 3DCT HD[2] images were acquired with the Discovery IGS7 OR to better understand the vascular anatomy (Figure 16-1).

Fig 16-1. Intraoperative 3DCT HD[2] image

We placed a temporary clip to mark the location and performed an angiogram to acquire more accurate images of blood flow dynamics such as the position of the shunt and the early venous filling (Figures 16-2 and 16-3).

We exfoliated the venous pouch all around and coagulated the feeder until the red vein disappeared. Cerebrovascular angiography scan proved that the shunt had disappeared (Figure 17). No neurological deficits were observed and the patient was discharged from the hospital.

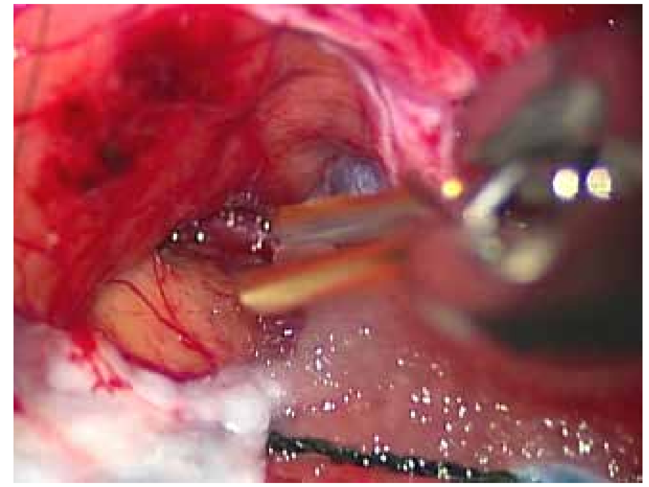

Fig 16-2. Intraoperative photo of a temporary clip

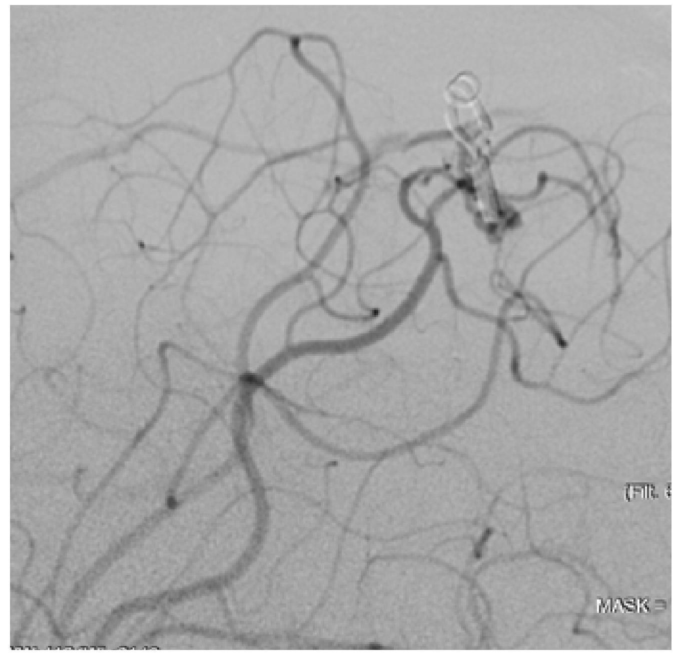

Fig 16-3. Preoperative DSA after the temporary clip

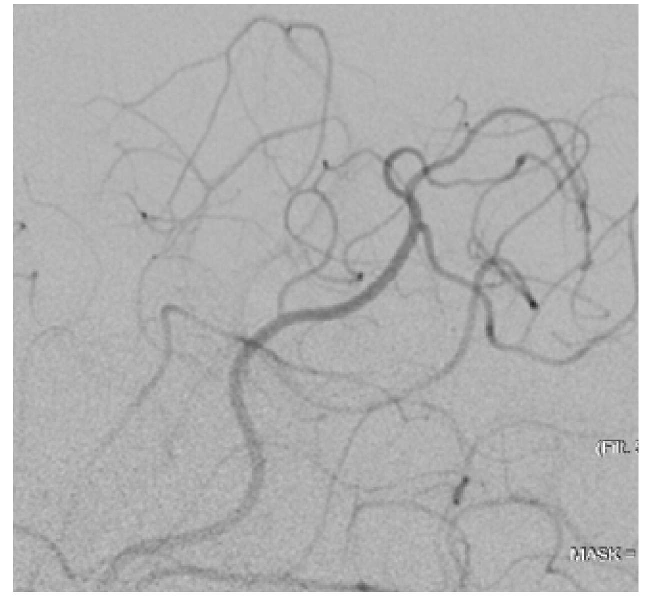

Fig 17. Postoperative DSA confirmed the disappearance of the shunt

In a case of pial AVF where it's difficult to distinguish between the shunt blood vessel and surrounding passing arteries, it is considered that the shunt blood vessel can be grasped and preserved more safely and accurately by performing the surgery in a hybrid OR theatre.

Conclusion

This paper described an example using GE Discovery IGS 7 OR in a open brain surgery case at our hospital and discussed its clinical advantages. Building a hybrid operating room is a major investment that not all institutions can readily afford. I think that discussions should be held across clinical departments so that the use of the facility can be maximized to deliver better patient outcomes. Our hybrid operating room is used every day and we are confident that it is a success in Japan.

1 Maquet Magnus table and skull clamp are sold by Getinge. The compatible accessories are Skull Clamp support 1005.48B0 and Skull Clamp 1005.49B0.

2 3DCT HD is an option sold separately. Includes 3DXR. Requires AW workstation and Volume Viewer.

Case Report
IGS 6
3DCT HD

Spinal Dural Arteriovenous Fistula with an Innova IGS 6*

Courtesy of Dr Joe Leyon, St George's Hospital, London (UK)

Patient History

A 73- year old patient presented with insidious onset but progressive bilateral leg weakness. History and clinical examination confirmed findings in keeping with myelopathy.

Strategy of diagnostic investigation: to evaluate the spinal cord to see for any cord signal change, vascular abnormality or any other pathology.

Fig 1. MRA showing hypertrophied spinal venous vasculature

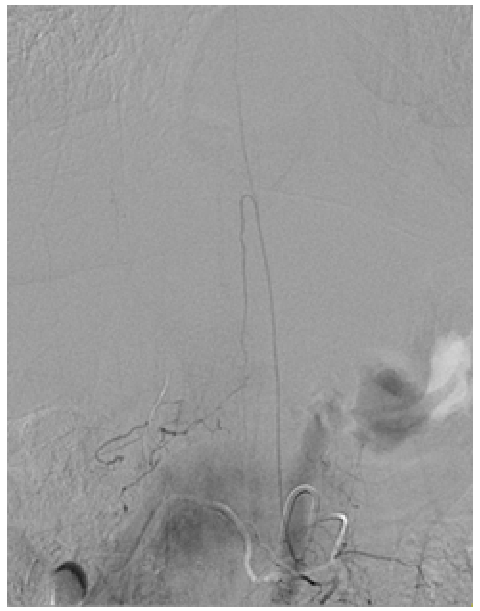

Fig 2. DSA showing the Adamkiewicz artery.

MRA findings

Patient had a MRI that showed long segment central cord signal change and vascular flow voids indicating the presence of an underlying arteriovenous fistula.

He was then referred for a spinal MRA. The spinal MRA confirmed hypertrophied spinal venous vasculature, highly suspicious of an underlying spinal dural arteriovenous fistula. A definite shunt was not identified on the MRA (Fig 1).

Angiographic study

The spinal angiograms were done using a Mickelson catheter. The artery of Adamkiewicz was identified arising from the left L1 radicular artery. The artery of Adamkiewicz was also collateralised from the right L1 radicular artery (Fig 2).

The fistula was identified under the left T5 pedicle (Fig 3).

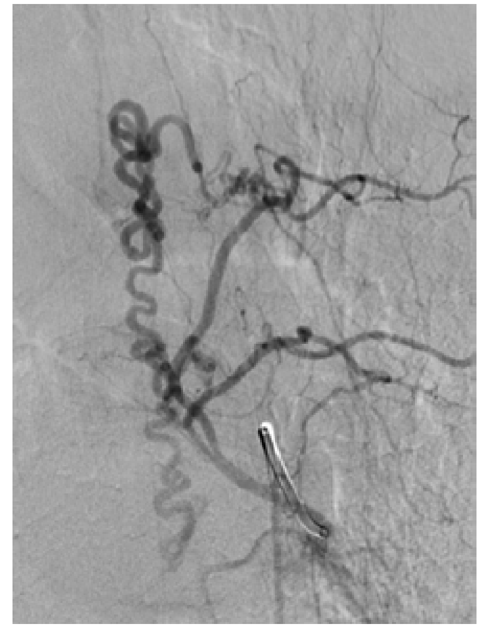

Fig 3. Identification of the fistula under the left T5 pedicle.

A 3DCT HD[1] was performed with a manual injection of 14mL of contrast for a 28deg/s spin. A radiculomedullary feeder was identified on the same injection demonstrating the fistula, but the exact vascular architecture of the fistula was unclear.

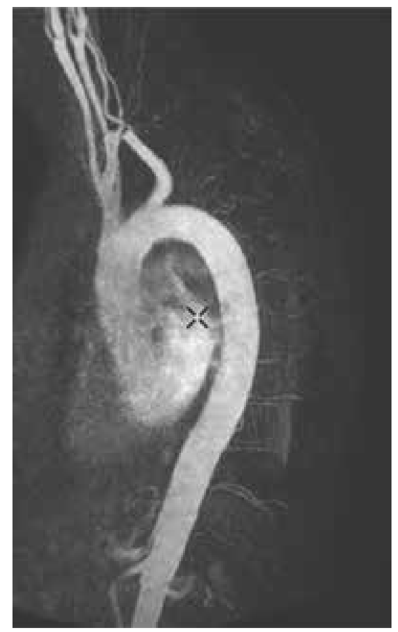

Fig 5. Post-op MRA showing fistula obliteration.

Fig 4. Embo ASSIST[2] colorizes the radicular artery (yellow) and the anterior spinal artery (blue).

The Embo ASSIST[2] solution allowed to segment the vascular tree and colorize the radicular artery leading to the draining vein of the fistula (yellow), as well as the anterior spinal artery (blue). Both the feeding artery to the fistula and the anterior spinal axis feeder derived supply from a single radicular artery (Fig 4).

An embolisation strategy would be to achieve distal microcatheter positioning in the fistula or immediately proximal to the fistula to achieve venous penetration into the fistula to occlude it but of even more importance, to prevent reflux and penetration of the embolic material into the anterior spinal axis.

Historical practice of the hospital for the treatment of spinal dural arteriovenous fistula is neurosurgical; hence the patient was treated with direct microsurgical obliteration.

Patient outcomes

Post op MRA showed obliteration of the flow voids and the patient is awaiting clinical recovery (Fig 5).

Conclusion

"The 3DCT HD[1] with Embo ASSIST[2] helped me to better understand the anatomy of the arterial feeders and better assess risks with embolisation."

"I would like to thank the radiographic team at Atkinson Morley Neurosciences, St George's and in particular Patricia McCutcheon and Stella Howchin for their skills and knowledge in radiography techniques and image acquisition. They make it all possible."

*Innova IGS 6, configuration 630

1 3DCT HD is an option sold separately. Includes 3DXR. Requires AW workstation and Volume Viewer.D

2 Embo ASSIST solution includes FlightPlan For Embolization, Vision 2, VesselIQ Xpress, Autobone Xpress and requires AW workstation with Volume Viewer, Volume Viewer Innova. These applications are sold separately. May not be available in all markets. Refer to your sales representative.

DOC2554159

Digital tools for lower limbs

Digital tools supporting endovascular care

The Paris Hospital Group Saint-Joseph combines the site of Saint-Joseph, in the 14th district, and Marie Lannelongue Hospital at Plessis-Robinson. It is one of the most important European centres of vascular surgery, hosting many specialists in the aortic, arteriovenous fistula, venous and peripheral domains. The centre is equipped with a Discovery IGS 7*.

*Discovery IGS 7, configuration 740

Yann Gouëffic, MD, PhD, is a professor of vascular surgery in the Vascular Center at Groupe Hospitalier Paris Saint Joseph, Paris, France. Pr Gouëffic received his MD and PhD from the Nantes university and completed his education from Paris university hospitals and Hope Heart Institute (Seattle, USA). Pr Gouëffic is the former chief of department of vascular surgery at university hospital at Nantes, France, from 2011-2019.

Pr Gouëffic performs endovascular and open procedures for peripheral arterial diseases with more than 20 years of experience in this field. His clinical interests include lower extremity arterial disease, endovascular revascularization, wound healing and amputation prevention.

Pr Gouëffic is very involved in research. He is the author of numerous peer-reviewed original and review articles and he is a reviewer for different journals. He has consulted on the regulatory pathway and pivotal trials for many vascular devices, as well as participating in numerous meetings with the HAS (French National Authority for Health) and he has testified at HAS and FDA panel hearings.

Pr Gouëffic is a member of the French Society of Vascular and Endovascular Surgery and the European Society of Vascular Surgery. He is a co-director of the Paris Vascular Insights meeting. He serves as the editor of the L'Interventionnel magazine.

Digital tools for lower limbs

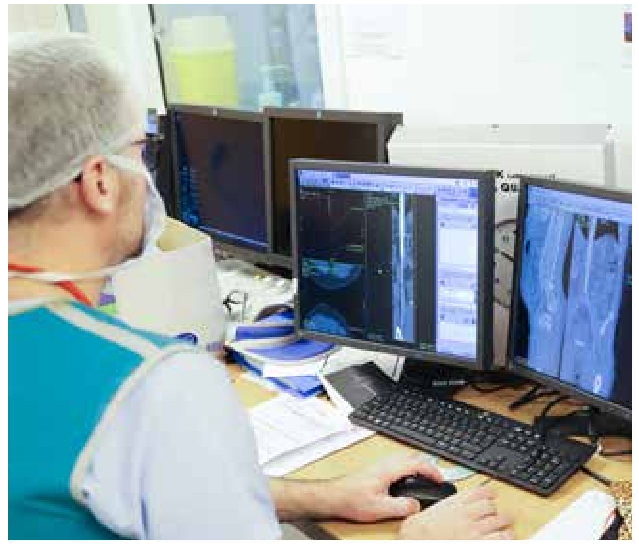

Fig 1. Review of the planning on the AW in the control room before the intervention

Fig 2. Lower limb recanalization using CT fusion.

How digital tools help with managing procedures

"*Thanks to the technology embedded in the Discovery IGS 7 we can produce the highest definition pictures, enhanced by the CT/fluoroscopy fusion and the digital zoom features*", explains professor Gouëffic. "*Advanced applications such as image fusion have already been adopted for the treatment of the aorta but their use in peripheral care is also essential for the technical success of the procedure.*"

Recommended by the European Society of Vascular Surgery, the CTA is a crucial evaluation for peripheral artery disease, allowing not only the characterisation of the lesion to be treated, but also the exploration of related damage, while identifying the most appropriate access (femoral, radial, brachial, etc.). To analyse the CT scan (Fig 1), the practitioner must have access to a user-friendly workstation. Vessel ASSIST[1] on the Advantage Workstation (AW) allows the reconstruction of vessels in 3D, the modification of centrelines at different planes, the automatic identification of vessel contours and the marking of the particular site (proximal/distal) of lesion for treatment, as well as their exact dimensions and presence of calcification. This augmented reality provided by the workstation must then be transferred to the operating theatre. "*Whether the operation is planned at Marie Lannelongue or at Saint-Joseph, we usually do a thorough planning on the AW workstation in order to fuse this planning with the low dose fluoroscopy during the procedure*", continues professor Gouëffic (Fig 2). Thanks to the fusion guidance, the radiation dose can be reduced by limiting the number of DSA sequences and by working with a low frame rate such as 3.75 fps.

After the CTA planning on the AW and when the patient is on the table, the team at St Joseph routinely performs an Innova Breeze[2] acquisition, which is a subtracted bolus chase of the whole leg(s) with diluted contrast. The result is matched with the CTA analysis to make any corrections to landmarks. It especially allows the initial strategy to be re-examined, for example regarding the level of catheter re-entry or the number of patent leg vessels.

"*I find it absolutely essential to begin femoral-popliteal procedures with a bolus chase. Furthermore, thanks to Innova Breeze[2], it is possible to save both radiation dose and iodine contrast*", claims Yann Gouëffic. "*We select a frame from the Innova Breeze[2] acquisition and the table and detector automatically reposition themselves at the position the frame was taken. Then, we use this frame as a roadmap for catheterization of the deep or superficial femoral artery. As there is no need to acquire new DSAs to visualise the lesion, we significantly save radiation dose and contrast for the patient.*" (Fig 3).

...

The AW Server standardises the practice between two sites

Since the start of the pandemic, the need for seamless integration of digital tools between remote sites have grown exponentially. Despite their distance of only a few kilometres, the exchange of information between the two sites hasn't been ideal. "*Although Marie Lannelongue deals more with aortic disease and major surgery, and Saint-Joseph focuses more on peripheral cases, there is an overlap of specialties between the two sites. I have to do many round trips for MDT, for consultations, and even to perform operations. In my practice, the AW server allows me to examine the CT angiograms in my office, prepare my vessel planning and my landmarks, which will help later during the fusion with the fluoroscopy, and to transmit this planning to different stations on the network*", says professor Gouëffic appreciatively (Fig 4).

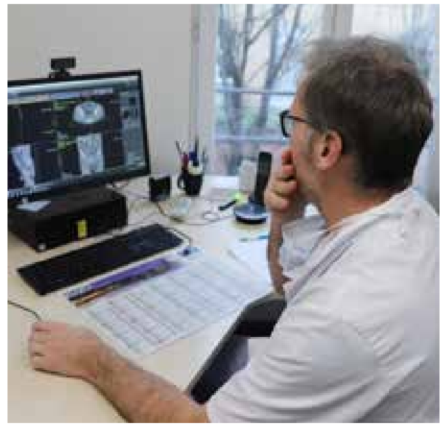

Fig 4. CT angiogram analysis and fusion preparation directly in the office thanks to the AW Server..

Pr Yann Gouëffic and endovascular research

Pr Gouëffic team is active on the endovascular research front. "*We are currently starting a randomised monocentric study with General Electric Healthcare's support to demonstrate the clinical benefits of using Innova Breeze and augmented roadmap in endovascular treatment of peripheral arteriopathy. We expect to report decreased radiation, and more importantly decreased amount of iodine when using this imaging workflow in these patients who are often diabetic and renally impaired*", as Pr Gouëffic explains.

Fig 3. Automatic positioning of the table and detector based on Innova Breeze[2].

The statements by GE's customers described here are based on their own opinions and on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist, i.e. hospital size, case mix, etc., there can be no guarantee that other customers will achieve the same results.

1 Vessel ASSIST solution includes Vision 2, VesselIQ Xpress and Autobone Xpress, and requires AW workstation with Volume Viewer and Volume Viewer Innova. These applications are sold separately.

2 Innova Breeze is optional feature. Not available on all IGS configurations

DOC2554160

5 Steps to treat lower limb occlusions using Vessel ASSIST[1]

Courtesy of Pr Yann Gouëffic, Vascular surgeon at St Joseph Paris (France)

Patient History

49-year-old male presented with decompensated non-insulin-dependent diabetes and decubitus pain in the left lower limb, no trophic disorders. There were two types of lesions: a relatively short 1cm one from the origin of the left common iliac, and a relatively short thrombosis in the left Hunter. The patient was categorized Rutherford stage IV with the limb prognosis involved. An outpatient treatment under local anesthesia and sedation was proposed.

Endovascular treatment began with the most distal lesion (superficial femoral artery) then treatment of the iliac lesion. Whatever the complexity of the lesions, it is important to always consider this approach:

1) What type of lesion is it?
2) Which access is the best?
3) How to cross the lesion?
4) How to prepare the artery?
5) How to treat the lesion?

For this patient, we went through the listed steps as follows:

1) For the analysis of the lesions, there are two extremely important examinations: the CT angiogram (recommended by the European Society, Fig 1) before the procedure and the Innova Breeze[2] acquisition (bolus chase) to confirm the lesion before starting the procedure.

2) Regarding the access, do we choose an antegrade puncture? Retrograde? Radial or brachial? It is the initial analysis of the CT angiogram that allows us to make a choice. Here we performed the puncture of the right common femoral artery under ultrasound then a crossover with a 6F intro (Fig 2).

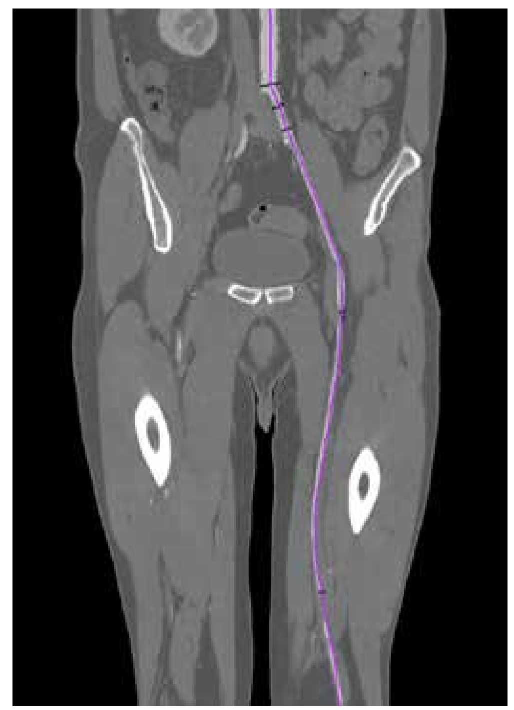

Fig 1. The centreline on the CT angiogram was manually edited inside the occlusion.

Fig 2. Setup of the room following the puncture of the right common femoral artery.

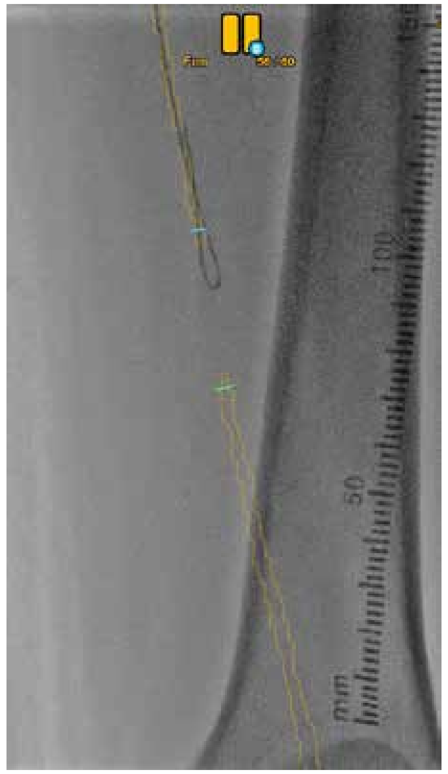

Fig 3. Crossing the lesion under CT fusion.

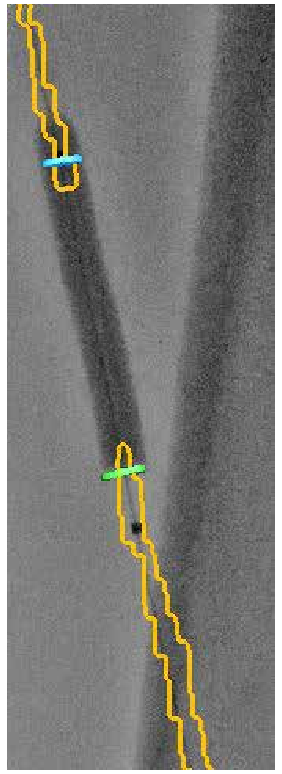

Fig 4. Balloon inflated using fusion for positioning.

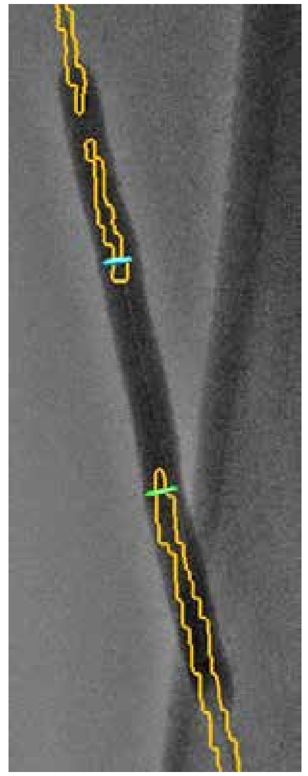

Fig 5. Treatment of the artery with an active balloon .

3) The third step is about the crossing of the lesion. Would it be intraluminal? Subintimal? With a support catheter? A Reentry catheter? Here we crossed the lesion intraluminally (Fig 3). Once the guidewire had passed the lesion, a 5x40 mm balloon was used as a support. The balloon passed the lesion on the guide and we injected contrast to check that we were in the correct lumen.

4) The artery preparation was started with the same balloon, for the sake of economy and speed. The balloon was inflated for 2 minutes (Fig4). By checking the preparation, we noticed a dissection on an under inflated artery.

5) Finally, for this TASC A and B lesion, a bare stent, an active stent, or an active balloon could be considered. As the patient was part of an ongoing study, he was treated with an active balloon (Fig 5). Stenting would be necessary in the event of failure or significant post-active balloon stenosis.

At the end of treating the first lesion, an angiography check was performed in two planes separated by 45° to verify the absence of any significant dissection. Finally, an Innova Breeze[2] acquisition allowed to check the quality of the revascularization, the absence of distal embolism and to assess that the blood flow was faster than previously.

The procedure ended with protected stenting in the left common iliac artery. A contrast media injection was performed to register the fusion with fluoroscopy then the stent was deployed under fusion control only (Fig 6). The final angiogram showed satisfactory revascularization.

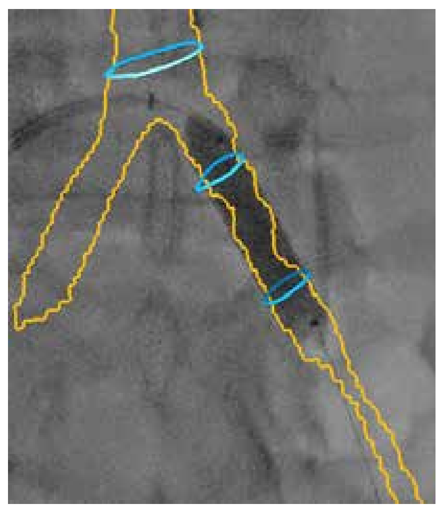

Fig 6. Deployment of the stent in the left common iliac artery under fusion guidance.

Benefits of fusion and Innova Breeze[2] for Lower Limb Treatments

With the active balloon, it is important to avoid a geographic miss, an area that would have been prepared but not treated, which would make this area prone to restenosis. Thanks to the two circles placed at the extremities (proximal and distal) of the lesion during the planning phase on the AW, the area to be treated was well located on the fluoroscopy. "*I think that the CT-fluoro fusion is very useful to do the crossover, catheterize the superficial femoral artery, prepare and treat the lesion and then to deploy the stent.*"

"*The Innova Breeze[2] acquisition is a key feature in our everyday practice, which facilitates procedures by lowering the dose of both radiation and contrast agent. It allows us to obtain descriptive imaging that shows the extent of the lesions before treatment (Fig 7) and the extent of the repair afterwards (Fig 8). We frequently use Innova Breeze[2] if we are having difficulty catheterizing the femoral tripod. I can reuse the frame corresponding to the femoral tripod and overlay it as a roadmap to catheterize the SFA, with automatic positioning of the table and the detector, without having to redo an acquisition. We could also have used Innova Breeze[2] if we had to do a retrograde puncture of a leg artery to recanalize the femoropopliteal thrombosis in a Safari fashion.*"

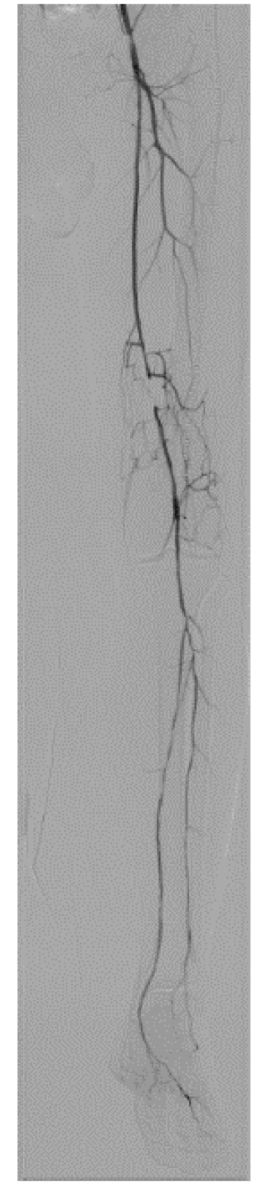

Fig 7. Innova Breeze[2] acquisition before the treatment of the left superficial femoral artery.

Fig 8. Innova Breeze[2] acquisition after the treatment of the left superficial femoral artery.

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2 Innova Breeze is optional feature. Not available on all IGS configurations

DOC2554164

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