Professor Matthias Prokop, Chair of Imaging Research, Radboudumc

From Molecule to Man to Population

The Radboud university medical centre (Radboudumc) in Nijmegen, the Netherlands aims to have a significant impact on healthcare; 'From Molecule to Man to Population'. With a 30-strong team, the Imaging Research group within the Department of Radiology and Nuclear Medicine develops imaging applications that bridge the gap between research and practice and help shape the future of healthcare. Professor Matthias Prokop, Chair of Imaging Research, explains how the Aquilion ONE™ and close collaboration with Toshiba Medical's engineers in Japan and Europe over the last five years continue to enable the team to advance techniques in functional imaging.

Radboudumc purchased an Aquilion ONE in 2011 to enable their team to advance research in functional imaging, recognizing the importance of this field for the future.

SYNERGY

"The market options available at the time meant that we could choose for speed (Dual Energy CT scanners) or coverage (Aquilion ONE). Software and development in functional imaging was in its infancy, so we expected to be able to contribute to developments. We were looking for a partner and had a good click with Toshiba Medical," said Professor Prokop. "Before making a final decision, we visited the company's engineers in Japan, because we wanted to know how much they listened to users. I find that very important, because the field only moves forward if you get a good interaction between users and engineers. What we found out was impressive, and convinced us that working with Toshiba Medical was the way forward."

Since then, the collaboration has steadily grown. Radboudumc Imaging Research share their thoughts about the future with the engineers in Japan and co-develop in some areas. Regular meetings in Japan and Nijmegen ensure the continuity of discussions about ongoing projects and fine-tuning of the imaging systems currently in use at the hospital.

SMOOTH INTRODUCTION

Before installation of their new Aquilion ONE, Radboudumc planned the positioning of the new system strategically to ensure easy access and optimal flexibility for use by the Emergency Rooms and poli-clinics alike. Installation of the scanner went fast.

"We could use the system within a short period of time," said Professor Prokop. "Training went smoothly, although the interface was substantially different to those of the scanner that we had used before. Due to this, we trained small groups of technologists and radiographers and expanded it to others, so that everyone felt comfortable."

EXPLORING NEW POSSIBILITIES

With the introduction of the Aquilion ONE, it became possible for the Radboudumc Imaging Research to collect functional, as well as morphological data for the first time. As well as its role in routine clinical practice, the Aquilion ONE is used to continually explore new possibilities.

"The development of any new techniques starts with a vision that we initially evaluate. We see what is missing, and then approach Toshiba Medical to discuss what is needed to make things a reality. So far, this has gone very well," explained Professor Prokop. "Toshiba Medical also implements our feedback on optimization into new software. I have been amazed by the speed, at which the feedback is implemented.

Brain perfusion imaging using the Aquilion ONE was introduced early on and is a classic area for testing a lot of new techniques in radiology. The ultimate goal in CT imaging of the brain is to eliminate the pre-contrast scan and scan with a lower amount of Iodinated contrast for indications of interest, e.g. stroke (but also many other indications for the brain) and then reconstruct from a series that costs no more dose than normal pre- and post-contrast brain scans everything required.

"With full brain coverage provided by Aquilion ONE, we can investigate stroke outside the classical field around the basal ganglia," said Professor Prokop. "Perfusion with the Aquilion ONE gives us a much higher detection rate of vascular occlusions in patients with intra arterial thrombolysis, as we do not miss peripheral occlusions. Malperfused regions indicate areas that we need to return to and include. It's easy to set up, works quite rapidly and doesn't delay our clinical process."

DEVELOPING NEW TECHNIQUES

Radboudumc Imaging Research have also been developing an interesting technique for a subset of particularly vulnerable patients. The One-Step-Stroke protocol: a single examination sequence, in which the neck CTA is part of the CTP. One-Step-Stroke imaging has the potential to replace CTA and CTP which saves radiation dose and contrast agent dose. It can reduce the amount of contrast required by almost half ([1], [2]).

"The nice thing about this technique is that it doesn't affect the qualitative values of the perfusion," said Professor Prokop. "In addition, we can perform bolus triggering for CT perfusion. In a patient with a slow circulation, a 60-second acquisition can stop too early before the contrast is optimally distributed to be effective. Using the Aquilion ONE for this type of technique, you can start a certain amount of scans (e.g. 20) after the contrast has arrived, which helps avoid artifacts."

"We are currently exploring combining that with subtraction; performing a CTA with initial pre-contrast scan, followed by the One-Step-Stroke technique, and finally subtracting in the neck region, where we can be hindered by some streak artifacts to scattering, because we are in the most difficult area of the body. However, by using subtraction, we can eliminate most of these," he added.

OPPORTUNITIES TO ADVANCE EXISTING APPLICATIONS

The Aquilion ONE as well as the Aquilion ONE ViSION Edition and Aquilion ONE GENESIS Edition offer full flexibility in planning scan protocols, which makes it ideal for perfusion studies.

"You can start with a short scan and continue scanning, overlapping 3D with a really high temporal reconstruction," said Professor Prokop. "We do that in patients with Arteriovenous (AV) malformations to find Tinnitus, for example. You can also perform scans every two seconds and every five (or so) seconds at a later phase, changing the amount of dose that you give for each of these phases."

Scanning with Toshiba's area detector CT's can be optimized to specific needs for different indications. The researchers at Radboudumc Imaging Research have developed a unique protocol for abdominal examination that gives better results than perfusion or diagnostic scans alone.

"A diagnostic scan interleaved with a perfusion scan gives the best of two worlds - That's possible on this scanner," he added.

Professor Mathias Prokop is one of the world's leading experts on body imaging. With a particular interest in new CT technologies, he has explored the boundaries of this modality for the last 30 years, and led many research institutes and projects worldwide.

Transferring new techniques like these to clinicians so that they understand the full implications of opportunities can be challenging. For the best results, Radboudumc pairs clinical- and radiology specialists, who explore this together.

Professor Prokop's dream for the future is to use CT perfusion for many of the indications that currently require a multiphasic CT. However, he admits that many prerequisites must be fulfilled before that will be possible.

"We have recently joined forces with Toshiba Medical's engineers to develop a very potent noise reduction algorithm that enables high resolution CT perfusion imaging, at a much higher resolution than we can achieve at the moment. It allows us to do excellent 4D analysis of the vasculature in the region of interest and is a very important step forward," he remarked. "In transferring this to other areas of the body, such as the lungs or abdomen; motion correction becomes a key factor. The Aquilion ONE scanners already have great motion correction in the abdomen and lung, which is good for subtraction imaging, but we are working to improve it further for CT-perfusion to create a totally new image quality."

SUBTRACTION

"We are really happy with the subtraction technique for the Aquilion ONE scanners. It's very versatile. We have used it routinely for pulmonary angiographs for more than a year. In the lung, it helps us find perfusion defects, which we then examine further; the enhancement of nodules; and areas of infection or active inflammation," he said. "One of the big advantages SURESubtraction is that you get a much better signal at a lower noise - around 40-50% less noise than with Dual Energy CT scanning techniques. We hope to see our noise reduction algorithm introduced in mid-2017. It's a very powerful tool that we think will become a 'game changer'. We believe that subtraction will be very important in the future."

"I would, however, like to see even better image registration for the lung that enables not only the lung parenchyma, but also the vessels, to be registered perfectly or almost perfectly," he continued. "We can then use that information for many different things, like being able to reduce the amount of contrast administered, by imitating a technique known from Dual Energy CT - We can create good images by taking information from an island map; superimposing this onto multiple, original, contrast-enhanced CT images; and combining this with noise reduction. Toshiba Medical has already implemented the first step of this in the abdomen and we hope to see it in other areas of the body in the future."

PIVOTAL IN THE FUTURE

Over the next decades, Professor Prokop anticipates that radiology, and medicine in general, will become far more computer-supported, with a great deal of routine work automated and accelerated, and the role of radiologists more consultancy-based. For CT, he believes that spatial resolution could improve further in the coming years, but finally will be limited. And that the biggest focus will be on software development. In addition, he thinks that the introduction of quantum photonic detectors could optimize functional imaging and routine work, but will take a while to emerge.

"Streamlining our workflows will be supremely important and will help us make the right decisions. High-end imagining techniques will be pivotal in this," he concluded.

References:
1. M.T.H. Oei, F.J. Meijer, W.-J. van der Woude, E.J. Smit, B. van Ginneken, M. Prokop and R. Manniesing. "Interleaving Cerebral CT Perfusion with Neck CT Angiography. Part I: Proof of Concept and Accuracy of Cerebral Perfusion Values", European Radiology.
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