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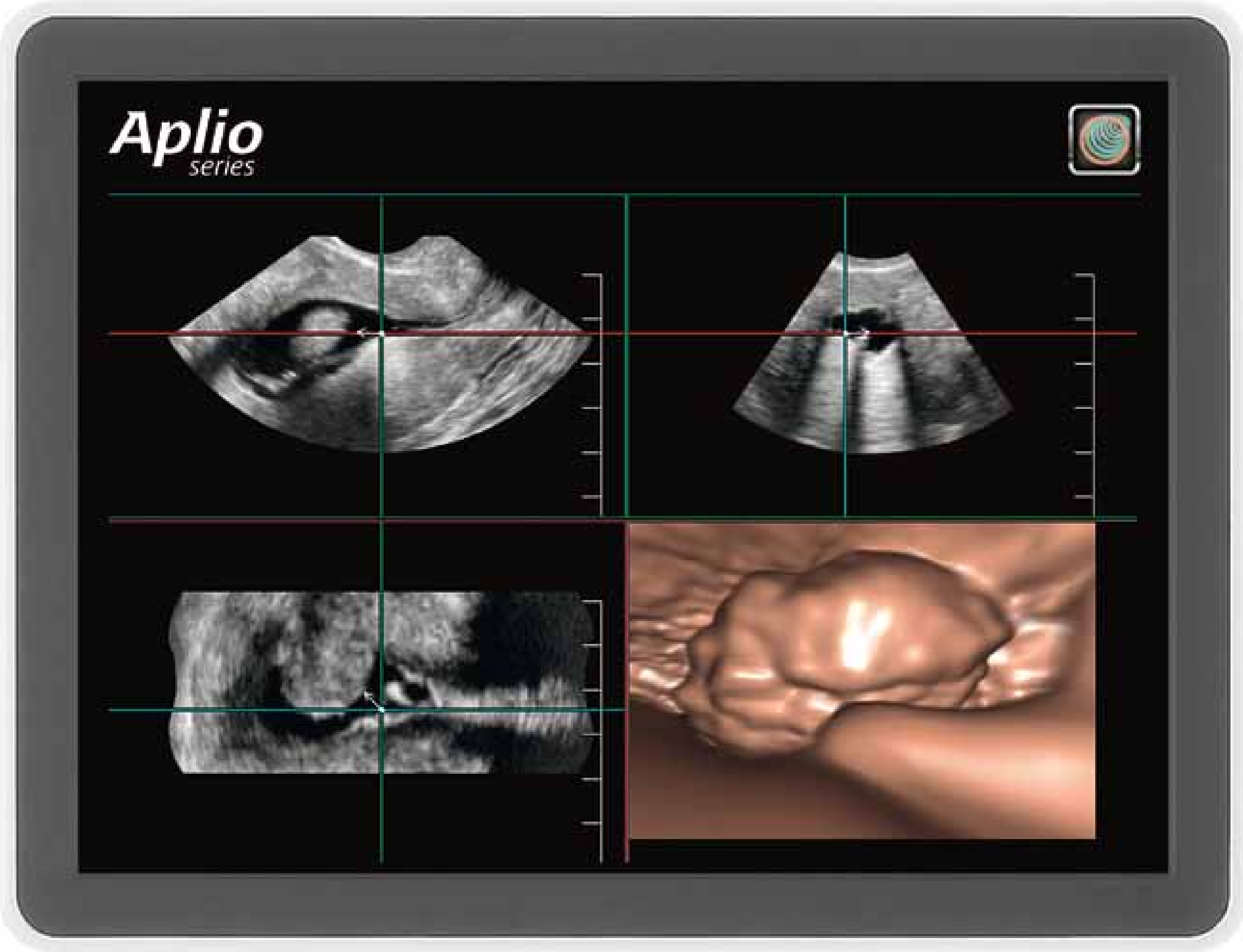

CT
From coronary CTA to myocardial perfusion

Ultrasound
Technology that rocks – the new Aplio series

X-Ray
3D Road-mapping made easy with Infinix-i

MR
A Titan in cardiovascular imaging – the new 3T MRI

VISIONS

18 · 2011

Volumetric image of a uterus polyp. Perspective volume rendering with the new Fly Thru technique let's you virtually dive into 3D data sets to explore cavities, ducts and vessel with unprecedented resolution and detail.

TOSHIBA MEDICAL SYSTEMS

Imprint

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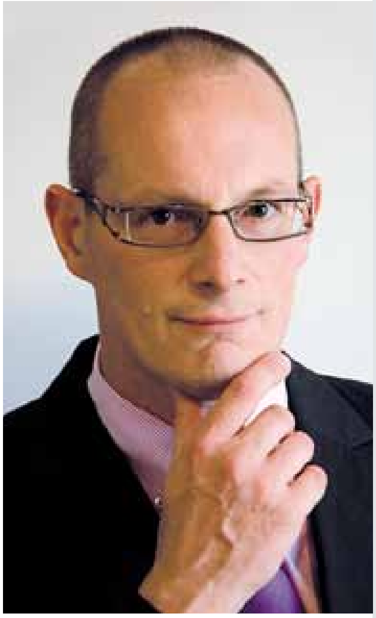

recently I read that engaging customers has become the core challenge for companies looking to forge a closer relationship with their target audience.

At Toshiba, we already recognized this many years ago when we defined our 'Made for Life' philosophy. Now we also refer to 'Partnership for Life' – a statement that expresses the importance we place on strengthening our bonds with you. As a world leader, we make extra effort to provide you with systems and solutions that are efficient and versatile. As a reliable partner, we want to help you and your team improve the quality of patient care.

This edition of VISIONS, once again, presents our beliefs in a concrete format. I see this magazine as a great way to engage with you; putting our brand, its innovations and proven clinical outcomes directly into your hands.

Innovations that include the new Aplio 300, 400 and 500 - a completely new generation of ultrasound systems with features "that rock" and a fresh and extremely smart, new look. The new systems come with "The BIG 4" innovative technologies: High Density Beamforming, High Density Rendering, Real Time applications and FlyThru. The latter enables you to virtually dive into a volume data set, to explore cavities, ducts and vessels from the inside, in 3D.

But there's more. What to think about the new X-ray Volume Navigation that takes 3D road- mapping to the next level and gives clinicians the tools they need to navigate complex anatomy with greater confidence and control. We also present clinical proof on radiation dose reduction techniques, diagnostic accuracy of 320-Row CT and clinical cases on Coronary CT angiography. Last but not least there are also articles with opinions and experiences of our customers and Toshiba news from all over the world.

I strongly believe that magazines have a special ability to connect, communicate and to engage. It is a real pleasure to produce and publish VISIONS, so that you can read it wherever you choose and at a pace that suits you best. The ultimate portable medium that requires no batteries - you'll never run out of power!

Kind regards,

Jack Hoogendoorn
Sr. Manager Marketing Communications
Toshiba Medical Systems Europe BV

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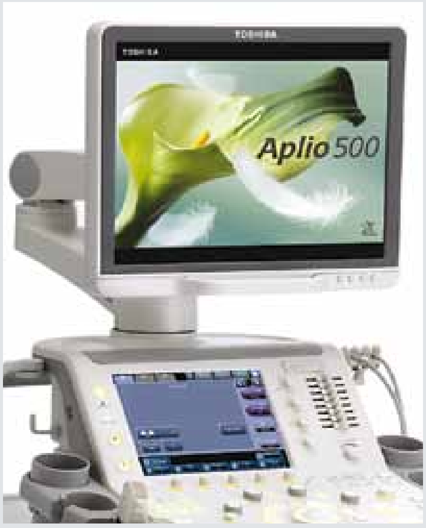

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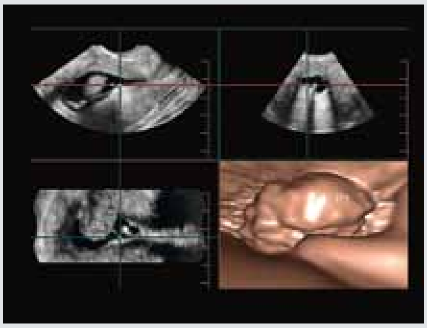

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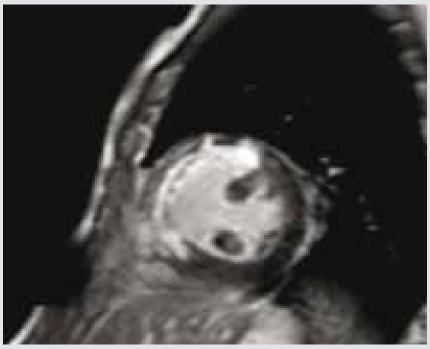

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The New Aplio Series

Re-Defining Ultrasound Technology

Toshiba's new ultrasound generation Aplio 300, 400 and 500 being launched at this year's World Congress of Ultrasound in Medicine and Biology (August 26–29, 2011, Vienna) promise "a giant leap forward" in image quality, workflow and innovative new technologies.

The new Aplio series offers an extensive range of clinical innovations presented in a fresh, extremely smart and ergonomic design. State of the art technologies and pioneering new features enhance all aspects of ultrasound imaging raising the highly successful Aplio brand to an entirely new level.

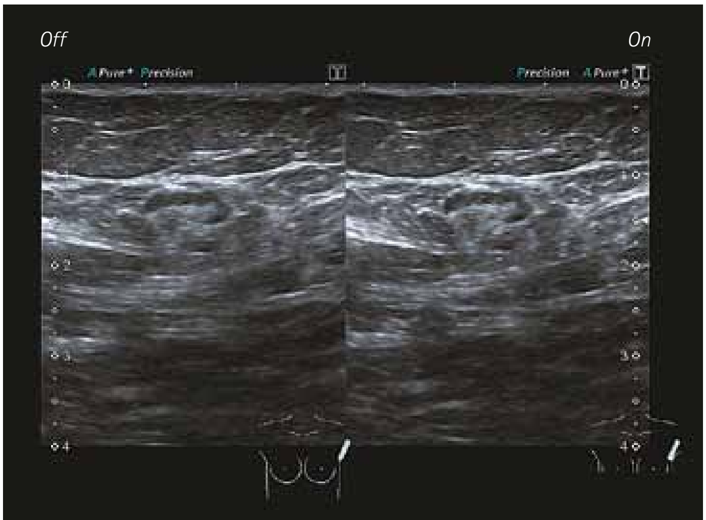
"In every aspect – image quality, advanced clinical applications, volume imaging, workflow and ergonomics – we have significantly enhanced the system's performance to further improve clinical precision, diagnostic confidence and department productivity", says Dr. Jörg Schlegel, Global Marketing Manager, Business Unit Ultrasound at Toshiba Medical Systems. Joop van de Kant, Clinical Marketing Manager Ultrasound, adds: "We not merely wanted to maintain our excellent reputation as the indisputable leader in image quality in the ultrasound market but wanted to chart new territory in order to offer our customers completely new diagnostic options."

The Big 4:
Aplio's New Technologies

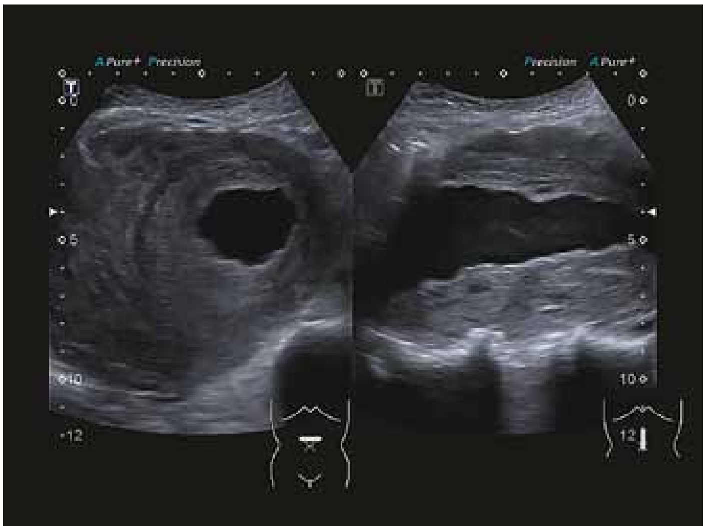
Four innovative core technologies ensure clinicians using the new Aplio will experience ultrasound with entirely new and improved diagnostic quality.

As the key feature of the new imaging engine **High Density Beamforming** uses the most advanced digital signal processing to control the ultrasonic beams more precisely and flexibly. Faster, more intelligent processing enables imaging at significantly higher frame rates and line density. The performance of clinically proven imaging technologies such as Precision Imaging, Differential Tissue Harmonics or ApliPure+ is further enhanced by the new beamforming architecture. This results in greatly improved spatial resolution with more dynamic range, better contrast and superior compounding. New image enhancement technologies such as Auto TSO (Tissue Specific Optimisation), that can automatically adjust the speed of sound settings to specific tissue characteristics, are valuable innovations in the clinical scenario. By analyzing ultrasonic images on the fly at various orders of spatial resolution, Aplio can more effectively separate structure from clutter and noise. Sharper outlines of lesions with more detailed resolution resultant from improved image quality increases diagnostic accuracy and clinical certainty.

ApliPure+



Tissue Specific Optimization

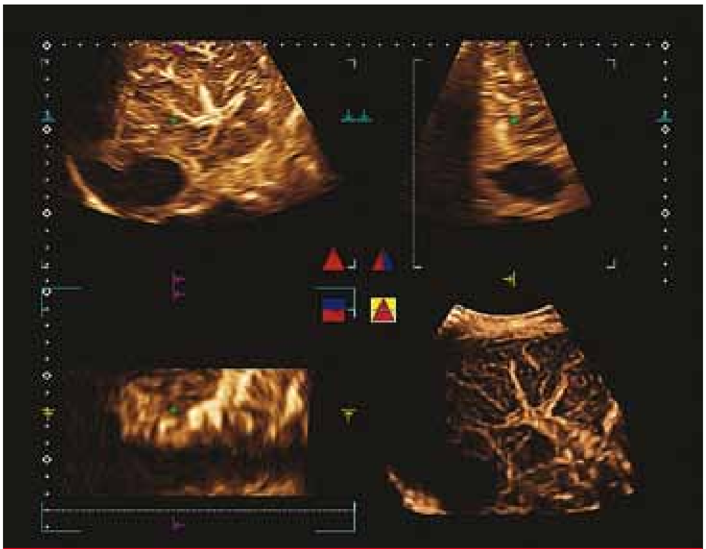


Precision Imaging

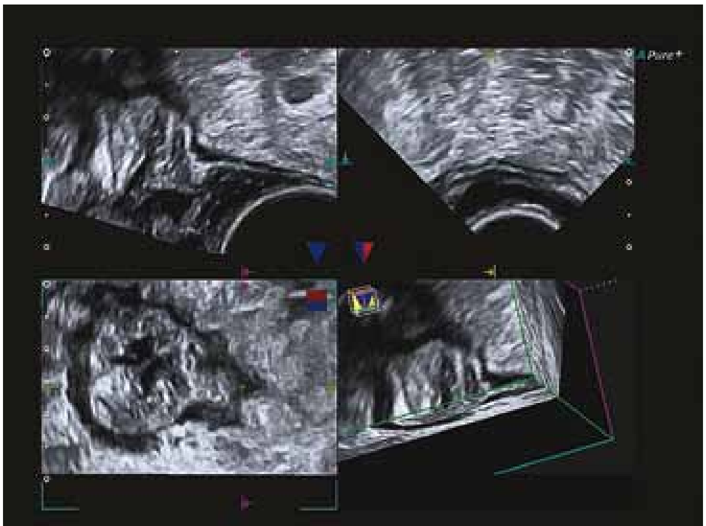
High Density
Beamforming

High Density Rendering

Toshiba's complete set of 3D and 4D applications utilise **High Density Rendering** technology with significantly improved volume acquisition rates, enhanced spatial resolution, as well as simple and fast volume manipulation and advanced rendering techniques. High speed processing allows data to be collected in shorter time. For the patient this means shorter breath holding duration, for the physician this results in more clinical detail with higher quality and resolution. Surface rendering adds the visual 3D effect to volumetric data displaying the surface of anatomical structures in an intuitive, easy to understand presentation format. This feature significantly aids in communication of results both to other clinicians as well as patients. Moreover, Multi-Planar Reconstruction (MPR) allows review of specific structures or regions simultaneously in multiple planes accompanied by a surface rendering or box volume image. The inclusion of advanced imaging techniques such as Precision Imaging, Differential Tissue Harmonics and ApliPure+ result in outstanding image quality with high spatial resolution in all planes. In addition to other features such as 3D/4D color flow, vascular imaging or 4D contrast imaging, **Fly Thru** is the most striking innovation in the field of volumetric imaging. Fly Thru utilizes perspective rendering which lets you virtually dive into a volume data set to explore cavities, ducts and vessels from the inside and in 3D. While conventional 3D imaging displays the surface of a given structure by parallel projection, Fly Thru uses perspective projection to display a given structure, emphasizing the near over the far field which means that proximal objects appear bigger than distal objects, much like in optical endoscopy.



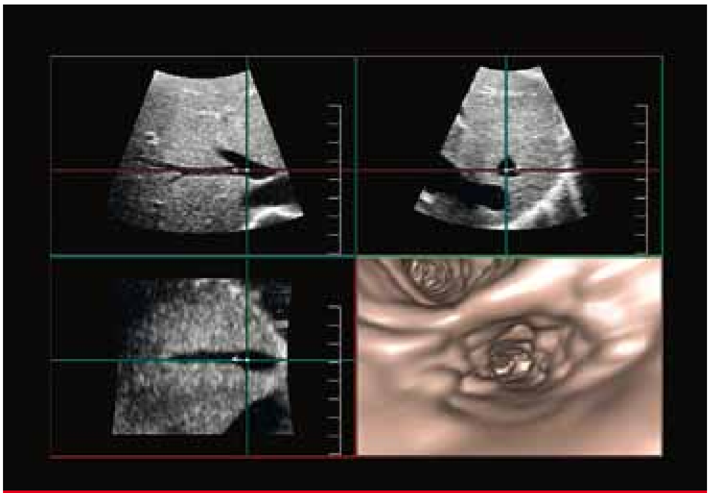
4D Contrast Imaging



Multi-Planar Reconstruction

Surface Rendering

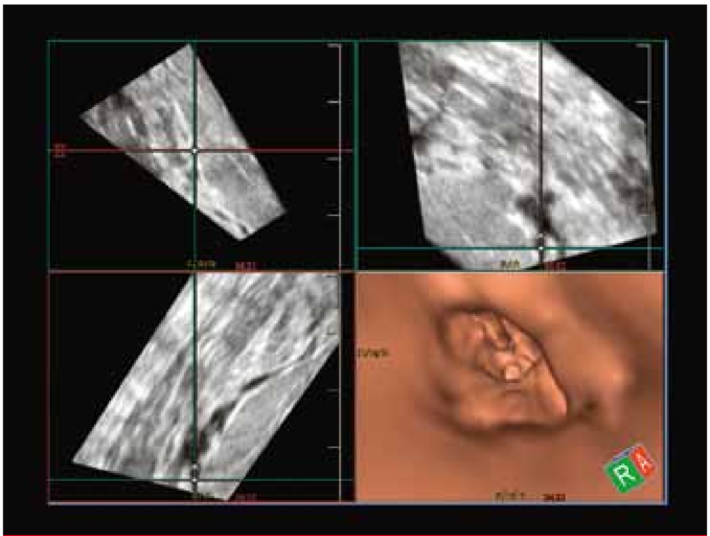
Fly Thru



Hepatic veins

Automatic volume navigation

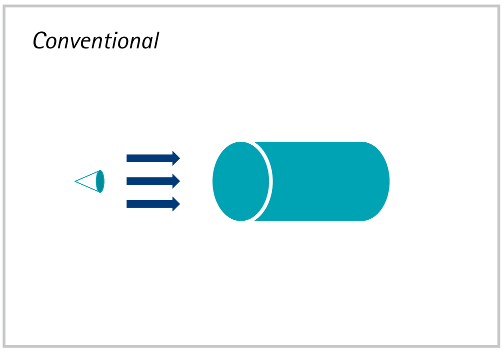
Fly Thru navigates you automatically through cavit ies, ducts and vessels. All you need to do is to set a start point anywhere in the volume to start the autopilot function. If needed, you can take over control at any time. Moving the trackball will change the flight direction. Using the console's rotary switches you can also browse the cavity fully manually.

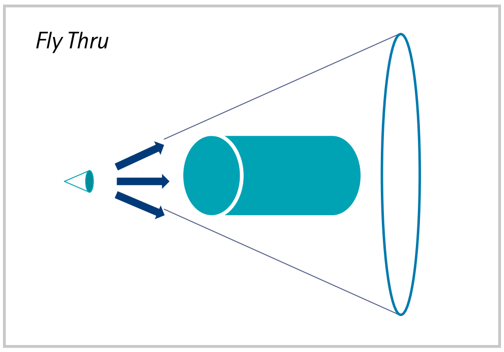


Lactiferous duct

Display and storage options

Thanks to its raw data functionality Fly Thru can be performed on any 3D volume data set acquired with your Aplio at any time. Similar to the MPR function, Fly Thru images can be supplemented by adding three orthogonal planes providing additional, cross-sectional information as well as a marker indicating the direction of navigation. Each flight can be stored as a movie clip for later review or presentation.





Conventional 3D imaging

Conventional 3D imaging makes use of parallel projection to display the surface of a given structure. All objects, proximal or distal, are displayed at the same size.

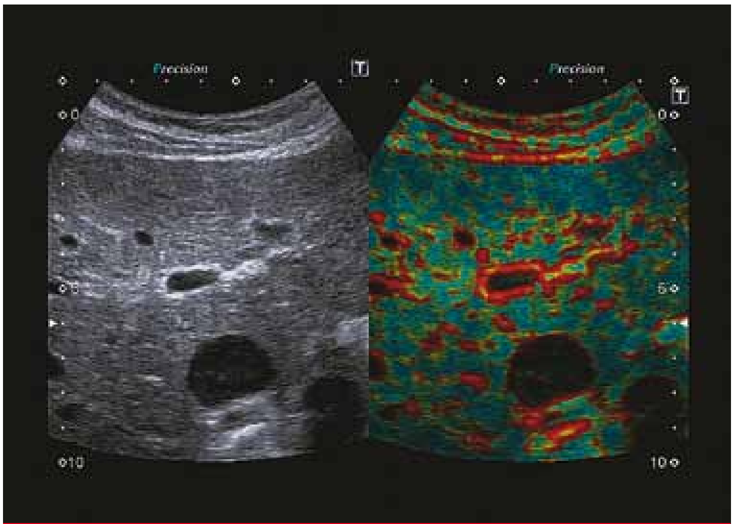
Fly Thru perspective 3D imaging

Fly Thru uses perspective projection to display the surface structure, emphasizing the near field over the far field. Thus proximal objects appear bigger than distal objects.

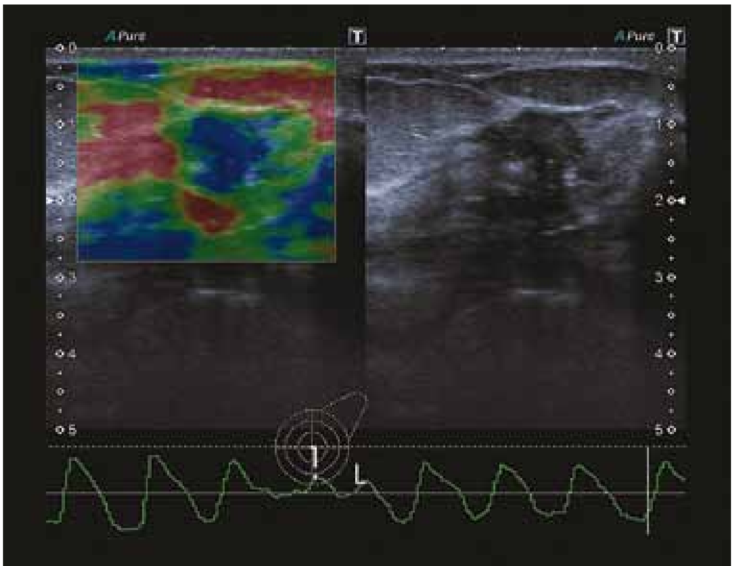
Realtime Application

A set of **Realtime Applications** utilizing the impressive processing power and speed of the new Aplio series enables the system to calculate more complex algorithms based on ultrasonic raw data in realtime. Aplio provides a complete range of exclusive, clinically proven technologies in easy to understand visual, parametric and quantitative formats such as:

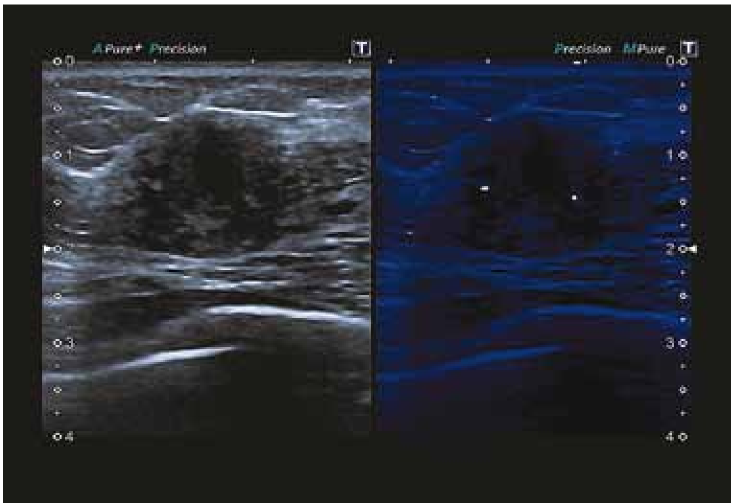
- **Live ASQ (Acoustic Structure Quantification):** A non-invasive tool to support assessment, characterization and follow-up of fibrotic and fatty tissue changes during a standard ultrasound scan.
- **Realtime elastography:** Toshiba's solution with raw data functionality assists in localizing and assessing the elasticity of palpable masses with high accuracy, sensitivity and reproducibility.
- **MicroPure:** This tool helps identify and highlight small calcifications, potential markers for malignancy in breast and other organs.
- **Contrast Enhanced Ultrasound (CEUS):** The CEUS applications allow the clinician to assess perfusion dynamics of ultrasonic contrast agents in a wide range of clinical settings. Depending on the system model, up to 24 transducers support contrast-enhanced studies including intra-operative or high frequency probes.
- **Wall Motion Tracking:** This proprietary speckle tracking technology provides immediate visual and quantitative access to regional myocardial wall motion. The sonographer can quantify parameters such as strain, strain rate or displacement – directly on the console or later on the workstation.
- **Auto IMT: Measuring the intima-media thickness (IMT)** of the carotid artery is crucial for assessing a patient´s risk for developing cardiovascular diseases. This easy to handle tool determines this parameter nearly automatically.



Live ASQ



Realtime Elastography



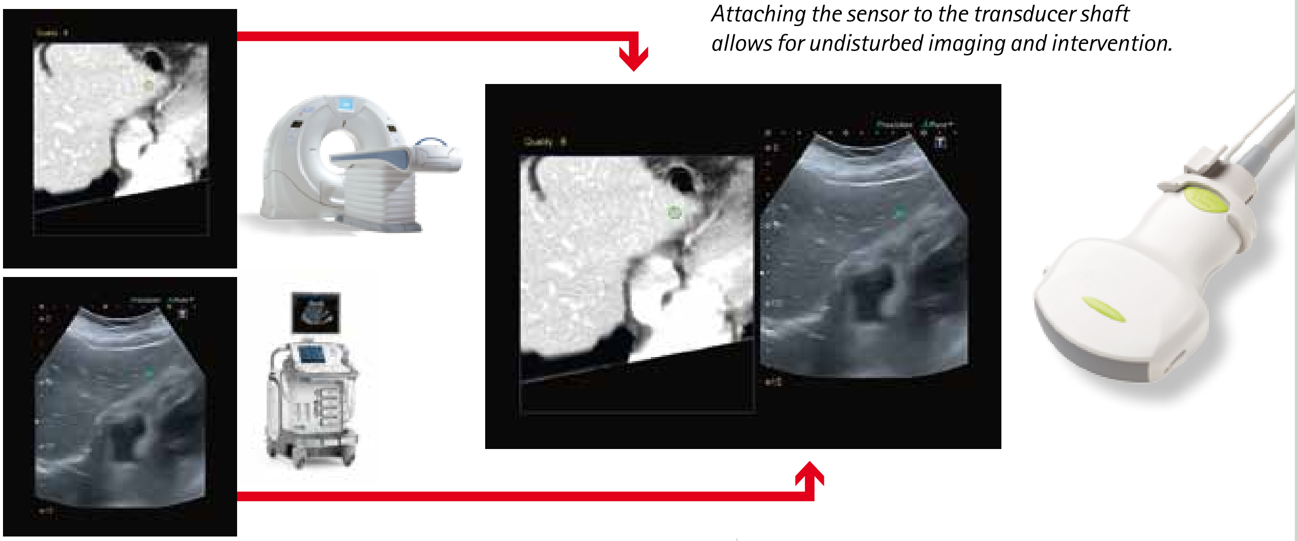
MicroPure

Smart Fusion

Smart Fusion is a powerful navigation tool that allows combining different imaging modalities onscreen in realtime. It reads 3D DICOM data sets from all major imaging modalities such as CT and MRI and shows the image of the corresponding reconstructed plane in realtime adjacent to the live ultrasound image.

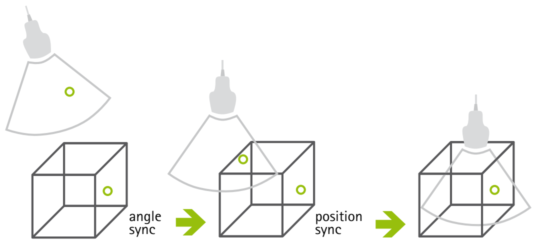
Position sensor

A magnetic position sensor with sub-millimeter accuracy allows for precise spatial correlation of different imaging modalities in realtime. Attaching the sensor to the transducer shaft allows for undisturbed imaging and intervention.



Merging modalities to improve confidence

Matching the transducer position with the pre-acquired 3D data set is a simple and quick two-step process. By moving the transducer over the region of interest you can now browse the area simultaneously in both realtime ultrasound and pre-acquired volume data. Intelligent target and marker points facilitate navigation in the region of interest.



iStyle Productivity

In addition to its superior imaging technology, Aplio features an outstanding set of ergonomics and workflow enhancement, the **iStyle+ Productivity** suite. The system's fully programmable panel and touch screen offer a more concise layout with innovative 3D multifunctional hard keys. The adjustable console and the fully articulating monitor arm help to create a fully ergonomic working environment. Moreover, several "quick" functions improve workflow and efficiency. The user programmable Quick Start menu allows adjustment of relevant parameter sets at

Quick Assist Protocols

a single touch of a button, reducing key strokes and disruptions to workflow by avoiding the need to change presets. QuickScan automatically optimizes the quality of 2D and spectral Doppler images by the push of a button. The utilisation of Quick Assist protocols ensure the same structured exam can be performed identically on all patients. This tool automatically launches a clear, easy to read on-screen menu that guides the clinician stepwise through the exam.

Quick Start Clinical Settings

Manage routine – explore new territory

Change is inevitable in today's healthcare environment, bringing expected increases in throughput and patient numbers, examination rates as well as discipline specific requirements, examination types and interventions. In order to help clinicians confidently address these challenges, a key focus in the development of the new Aplio series was easy integration in a wide variety of networked clinical environments. Consequently, Aplio offers full DICOM connectivity including all major service classes and IHE compatibility. To accommodate the necessities of flexible working conditions, the new Aplio systems can be extended with an external workstation providing full data access wherever and whenever needed. With embedded raw data functionality and a host of clinical tools, stored examinations can be reviewed, analyzed, reported and archived from anywhere in the hospital.

Sharing data and reports in an interdisciplinary scenario has been considerably simplified. A digital video interface connects the system to external devices such as monitors while comprehensive onboard facilities semi-automatically generate reports including measurements, charts, clinical images and text.

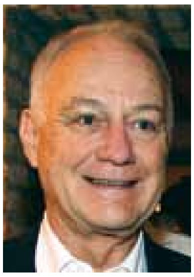
"Combining all these innovative technologies and features in this new ultrasound platform can truly be considered a revolution in the ultrasound industry. New tools such as Fly Thru – which is absolutely unique – will create new diagnostic opportunities which have the potential to re-define ultrasound imaging in the clinical setting", Jörg Schlegel sums up the new Aplio generation.

Export Clinical Data

Study Data

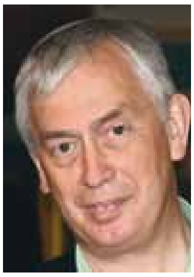
"Technology that Rocks"

Reviewing the new Aplio series and its new core technologies from the user's perspective as well as taking a look at how the technological advances incorporated translate into clinical benefits was in the hands of four renowned experts: Professor David Cosgrove, Dr Adrian Lim, Bill Smith and Dr Rainer Bald were the first to test the premium product Aplio 500. Their feedback can be summarized in one word: "Wow"!



"The Aplio 500 is doing a perfect job in ergonomics and functionality", acknowledged **Professor David Cosgrove**, Senior Research Investigator at the Clinical Sciences Department at Imperial College in London, UK. He highlighted a particular advantage of High Density Beamforming for abdominal imaging: the possibility to increase frame rate without losing resolution or detail. Professor Cosgrove was also enthusiastic about the special modes of High Density Rendering which offers advanced 3D and 4D options, and of course Fly Thru: "This is a fantastic new feature with impressive advantages. For me, one benefit of Fly Thru in the clinical setting is the improved communication with other physicians because of a better appreciation of complex structures." As far as the realtime applications are concerned, Professor Cosgrove's favourite is Acoustic Structure Quantification (Live ASQ) since it uses the pure raw data. And there is another small but relevant detail he points out: the option to anonymize patient data on the system which allows him to use these data easily for teaching or publication purposes – a great benefit for anybody involved in education and research. Professor Cosgrove's overall verdict: "Aplio 500 works with impressive speed, offers a beautiful, compact and powerful design and excellent imaging in all modes."

"Even though we are very satisfied with the B-mode quality of our current Aplio systems, the new Aplio 500 gives us even better spatial resolution and imaging contrast", says **Dr Adrian Lim**, Consultant Radiologist and Head of the Ultrasound Department at Charing Cross Hospital in London, UK. Dr Lim focused on Aplio's high frequency applications: "High Density Beamforming performs very well in breast examinations, the same holds true for MicroPure, a realtime application that automatically highlights detected calcifications as white spots in the masked 2D image. Moreover the elastography application is a perfect and extremely useful addition." Dr Lim was also very impressed by the iStyle+ Productivity features that significantly improve workflow in a busy clinical routine. "The best feature obviously is the four probe ports that are labelled with images of each probe", he states and adds "the whole system is much easier to manoeuvre and perfectly fits in a modern clinical surrounding. For me, the Aplio 500 rocks!"



Bill Smith, Head of Ultrasound Services at Clinical Diagnostic Services in London, UK, underlines that the "great sensitivity of the colour Doppler gives additional diagnostic confidence". Just like his colleagues he admires the superior spatial resolution of the 2D greyscale and is impressed by the "significant advantages of the volumetric imaging technologies incorporated in the new Aplio 500" that allows users to produce different anatomical planes very easily. Mr Smith expects quite a bit from realtime elastography, particularly in terms of examination of the endometrium, the myometrium or the diagnosis of an ovarian neoplasia. To support his enthusiasm for the new Aplio, Smith showed stunning images of Fly Thru in gynaecological and obstetric scenarios. "Fly Thru is opening up completely new perspectives for non-invasive imaging diagnostics in the ObGyn ultrasound lab. It offers the possibility to replace endoscopic examinations and may yield better results because the surrounding tissue can be seen at the same time as well.", he said and added that this technique may be suited for first trimester screening in pregnant women. "For gynaecological ultrasound, the Aplio 500 has the potential to become technology leader", Mr Smith concludes.

With the Aplio 500, **Dr Rainer Bald**, Head of Prenatal Diagnostics at Klinikum Leverkusen, Germany, produced fascinating fetal images of amazingly detailed resolution and diagnostic quality that left him almost speechless: "With the Aplio 500 I could see something that has never been visualized with diagnostic ultrasound before - the iris of the eye of a 22 week old fetus." Since the system displays smallest veins and arteries, measuring heart function is possible and extremely helpful in fetal screening. Bald emphasized that "High Density Rendering is a magnificent 3D/4D option that provides images of the fetus even better than current MR imaging techniques." Notwithstanding these options, the most important technique for his work remains B-mode. According to Dr Bald the Aplio 500 produces images of such a brilliant quality that the details that can be seen are "almost a bit scary" but offer amazing diagnostic possibilities. Dr. Bald relies fully on Aplio's image quality when performing intrauterine blood transfusions in case of fetal heart insufficiency. Just like the other three experts working with the Aplio 500 for the first time, Dr Bald is entirely convinced by the latest developments under Toshiba's new Aplio label.

Correlation of the Histopathology of Focal Breast Lesions with Ultrasound Derived Calculation of Strain Ratio

T. Fischer[1], A. Thomas[2]

Thomas Fischer, MD, PhD

Introduction

In recent years, the diagnostic confidence of B-mode ultrasound has been strengthened by innovations including tissue Doppler techniques and imaging of tissue elasticity. Elasticity is the ratio of the strain (pressure) required to induce relative elongation or distention (Figure 1). The intrinsic elasticity of biological tissue is altered by physiologic aging and pathologic processes such as inflammation and tumorigenesis. Real-time ultrasound with off-line analysis allows functional tissue elasticity changes to be depicted (Figure 2).

Elastography and Breast Lesions

The incorporation of elastography data improves the specificity of ultrasound diagnosis in the differentiation of focal breast lesions, especially beneficial in the presence of lipomatous glandular parenchyma and discrimination between BI-RADS category 3 and 4 lesions (Thomas A and Fischer T et. al. 2006, 2007 & 2010). Off-line analysis can be used for quantitative evaluation of tissue elasticity expressed as an elasticity quotient derived by means of tissue strain imaging (TSI) or strain ratio (SR) calculation.

Off-line, Independent Determination of Elastography Strain Ratio

The aim of this current investigation was to perform a retrospective evaluation by an independent second reader of B-mode ultrasound, mammography and elastography using subjective scores and calculated SR. Examples of the breast imaging, elastography images, SR determinations and biopsy procedures are depicted in Figures 3, 4, 5 & 6. The analysis by the second independent reader was performed on stored elastography raw data sets obtained in 201 patients with sonographically confirmed focal breast lesions. The elastography raw data and sonographic images where obtained using a Toshiba Aplio XG ultrasound system. The comparative investigation of Tsukuba scores (for the analysis of elastographic images) and BI-RADS categories (for mammographic and B-mode scan interpretation) contributed to further standardization of the method.

Confirmation of the Value of Elastography SR

The findings in this study support the premise that a second reading of ultrasound data, which is independent of the examiner who performed the sonographic examination, is feasible. The results confirm the inclusion of the elastography de-

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[2] Department of Obstetrics and Gynaecology and Ultrasound Research Laboratory, Charité – Universitätsmedizin Berlin, Germany

Fig. 1: A schematic depiction of the principle of strain imaging.

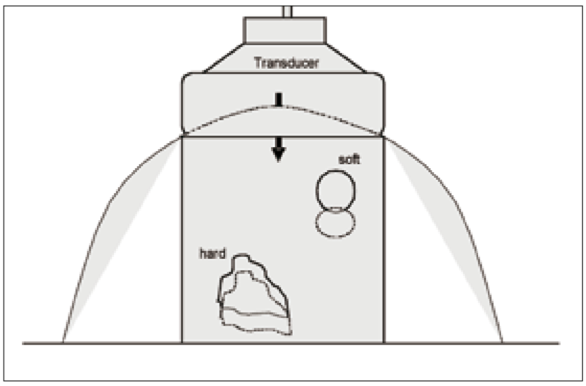


Fig. 2: Regions within the field of view can have their strain measured and a strain ratio (SR) can be calculated.

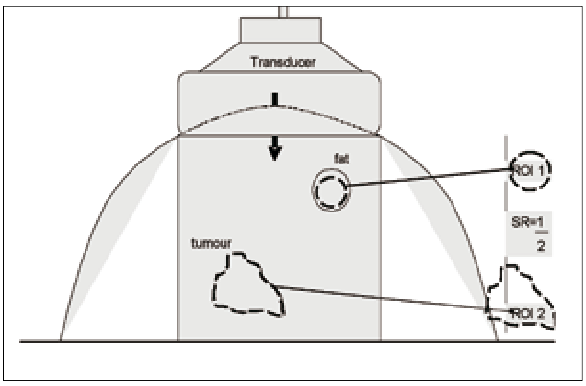


Fig. 3: B-mode scan of a breast lesion measuring 11 mm.

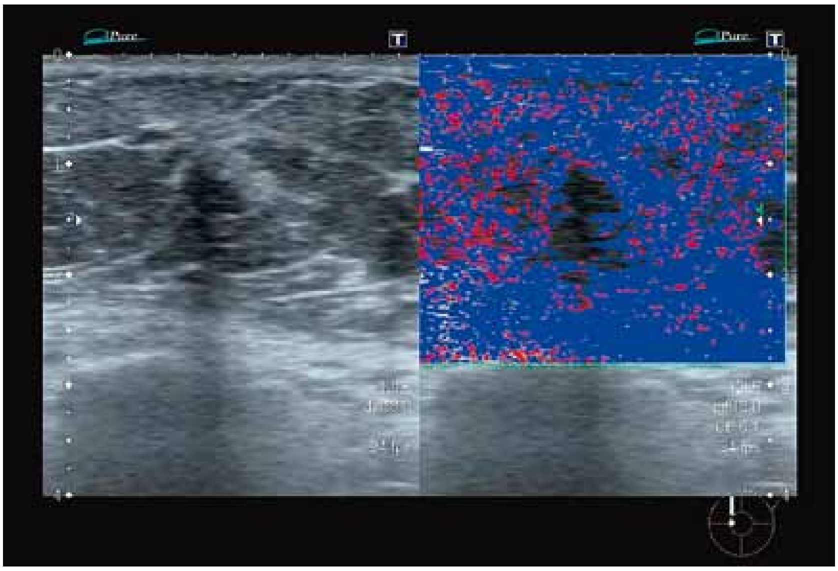


Fig. 4: The lesion is suspicious in the B-mode scan and realtime tissue Doppler image obtained without tissue compression.

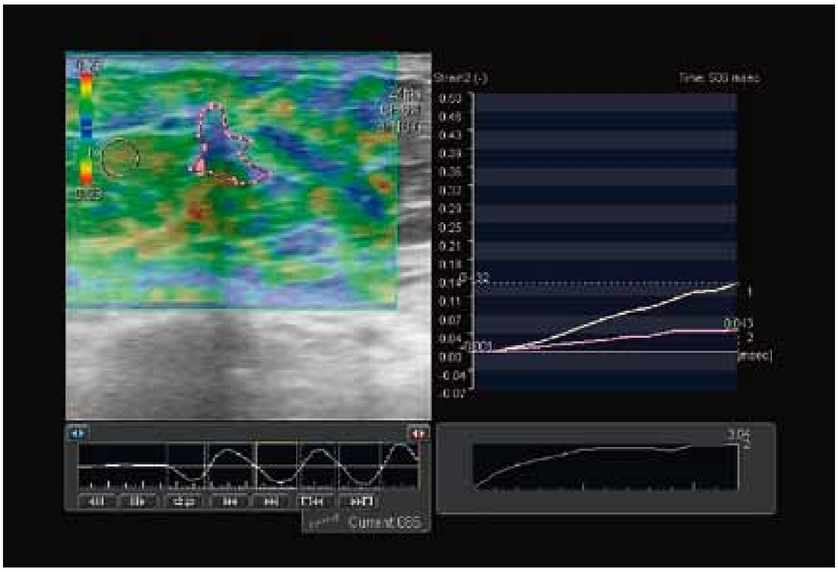


Fig. 5: Elastography shows a larger tumor extent (blue color beyond the tumor border) and a high SR of 3.04 of the entire area.

rived SR improved lesion detection sensitivity and specificity (95 % / 74 %) compared with B-mode imaging (85 % / 60 %), mammography (78 % / 62 %) and subjective interpretation of elastography images using the Tsukuba elasticity scoring system (85 % / 68 %).

Figure 7 shows the SR values for the various lesions pathologically determined in this patient cohort. SR calculation allowed reliable differentiation of invasive ductal and lobular carcinomas from fibroadenoma, mastopathy and other benign lesions. Based on this data an SR cutoff value

Fig. 6: Based on the elastography results, a core biopsy was obtained although the lesion had been classified as a BI-RADS 4 lesion. The histological result indicated an invasive lobular carcinoma.

of 2.27 was determined as one which allowed significant differentiation (p<0.001) of malignant from benign focal breast lesions. This value agrees with the cutoff value of 2.45 previously published for real-time sonoelastography (Thomas A et al. 2010). Such agreement confirms this as a technique with potential clinical value.

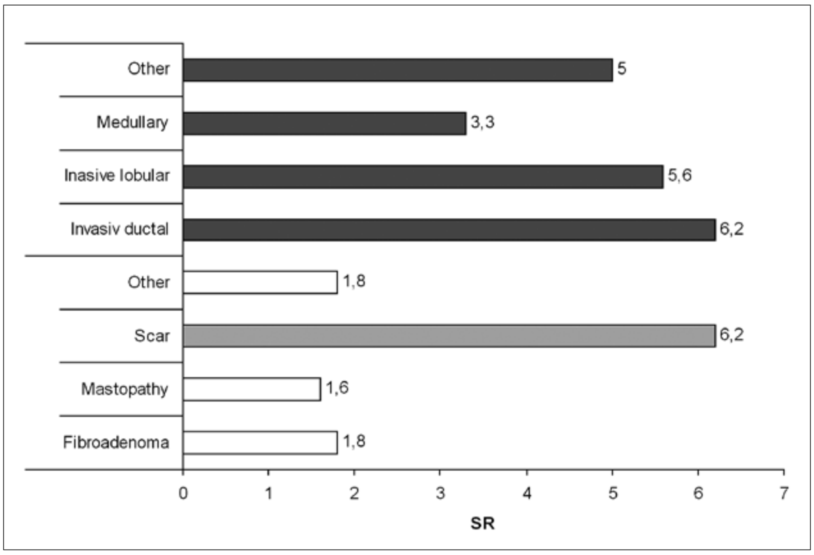
Unfortunately, in this study it was not possible to differentiate carcinomas from scar tissue based on SR value alone. The differentiation of these categories constitute a special situation currently requiring biopsy and histologic confirmation.

Other entities that require special attention are medullary and mucinous carcinomas and precancerous lesions. While the number of such cases in this study was low (n=17), these entities had lower elastography scores (between 3 and 4) and also a relatively low SR (3.3 for the group of medullary carcinomas, n=7). However, this value was still higher than that of benign breast lesions. Such cases require interpretation by the range of available ultrasound techniques, including elastography and SR, B-mode imaging, color Doppler and histological examination when the imaging data are inconclusive.

Conclusion

This study provides evidence that elastography data can be analyzed off-line, independent of the operator who acquired the data. It also supports that the incorporation of the calculated SR increases the sensitivity and specificity for the accurate classification of breast lesions and suggests there maybe prognostic value in an SR in the range of 2.27 – 2.45. Future prospective validation may provide a cutoff value with clinical utility which significantly aids in the confident diagnosis of breast lesions.

Fig. 7: This bar diagram shows the mean strain ratios (SR) calculated for benign (white bars) and malignant (dark gray bars) focal breast lesions; the scar (light gray) was the only lesion type which could not be differentiated by means of SR.



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Advanced Transvaginal 3D/4D Imaging of the Uterine Cavity Paves the Way for Ultrasound Hysteroscopy

B. Smith

Introduction

The development of transvaginal scanning (TVS) in the early 1980s had a major impact in terms of ultrasound examination of the female pelvis. It remains the principal imaging modality for assessment of the pelvic organs and associated gynaecological disorders. The diagnostic value of TVS and its major influence on clinical managements have been well documented.

The pioneering work of Smith, Craft et al (London) promoted the use of TVS in reproductive gynaecology, particularly as part of IVF and assisted reproduction techniques, from 1982 onwards. The role of TVS rapidly expanded to include aspects of general gynaecology and early pregnancy assessments. Extensive work carried out by Smith, McMillan, Farrugia, O'Riordan et al (London) in the early 1990s focussed on the benefits of TVS specifically in the investigation of abnormal uterine (post-menopausal) bleeding. TVS became an integral part of patient investigation at hysteroscopy outpatient clinics set up by the above personnel at North Middlesex Hospital and Whipps Cross Hospital, London.

The idea of transcervical infusion of saline in order to distend the uterine cavity presented obvious advantages in terms of outlining the size and shape of the cavity and demonstrating associated pathologies. The technique of saline infusion sonohysterography (SIS), or fluid ultrasound, was established by Smith and O'Riordan as part of the above clinics. On-going work over several years at that early stage confirmed increasing favourable levels of correlation between (2D TVS) SIS and hysteroscopic findings.

The role of TVS SIS techniques was significantly enhanced with the introduction of 3D ultrasound imaging. The ability to rapidly acquire a 3D volume and easily recall and manipulate the stored ultrasound data has proven to be of tremendous practical and clinical value. It was very quickly realised that 3D interrogation of the uterine cavity produced very precise imaging of its internal features once dis-

Fig. 1a: The basic clinical trolley setting showing the SIS balloon catheter, syringes and ampoules of saline, speculum, sponge holding tweezers, cleansing fluid and dressing pack.

Fig. 1b: Close-up of the inflated balloon on typical catheters used for SIS procedure.

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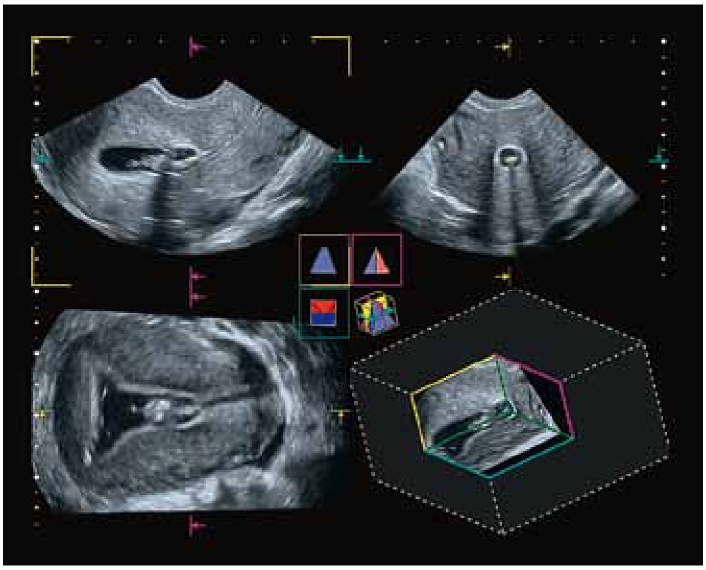


Fig. 2: Examples of typical image formats obtained from a single 3D sweep. These can be easily displayed pre- or post storage of acquired volumetric ultrasound data.

Fig. 2a: Multiplanar x, y and z (parasagittal, transverse, coronal) 2D anatomical sections plus block volume image display.

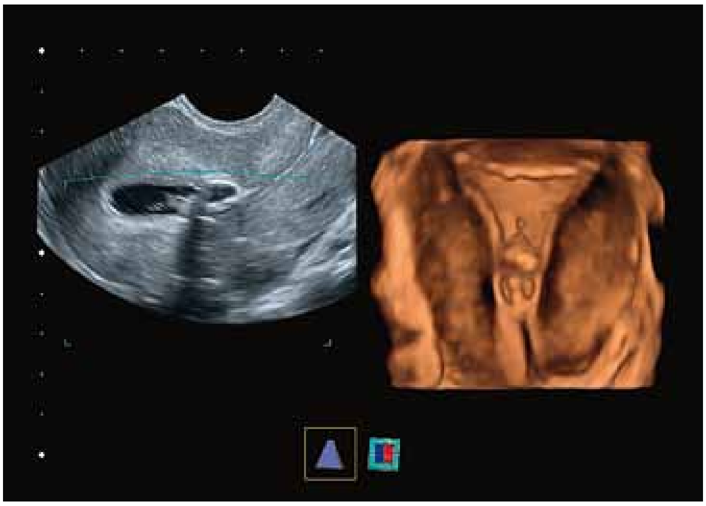


Fig. 2b: Composite 2D parasagittal plus surface rendered coronal anatomical sections.

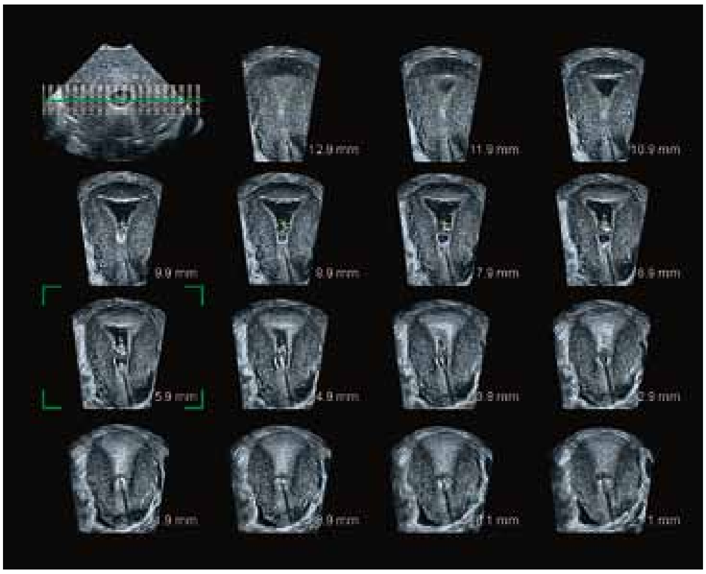


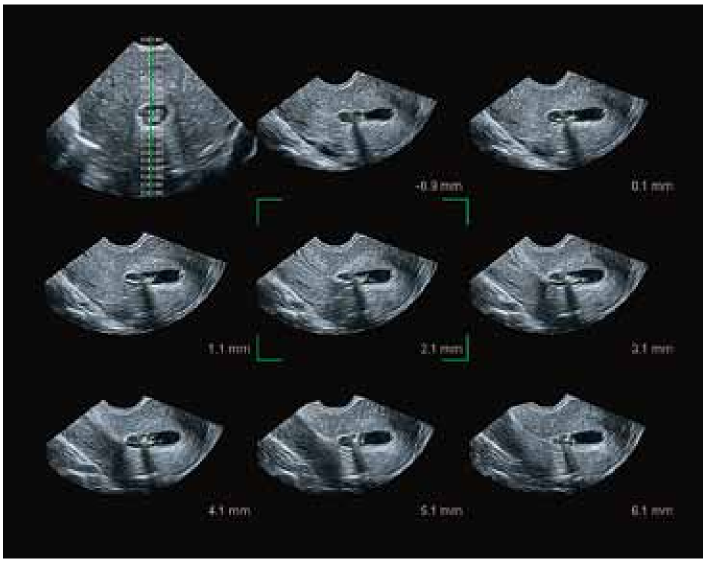
Fig. 2c: Multi View (tomographic) 3D anatomical sections – coronal 2D plane (15 anatomical slices).

tended by saline. More recent advances in surface rendering techniques have further increased the diagnostic capability of SIS examination. The very latest, state of the art Toshiba Medical Systems has moved TVS 3D/4D technology on yet another step – the Aplio 500 series provides the capability of Fly Thru ultrasound imaging thereby creating the true concept of ultrasound hysteroscopy.

Materials and methods

SIS is now an established procedure in many leading units. It is regarded as an integral part of TVS ultrasound and in experienced hands proves to be a relatively quick and simple technique. The whole procedure takes approx. 10–15 minutes on average which includes only a comparatively short time involving the the ultrasound imaging process itself.

Fig. 2d: Multi View (tomographic) 3D anatomical sections – parasagittal 2D plane (8 anatomical slices).



A simple clinical procedure set is required (figure 1a) and the technique utilises some form of narrow, soft balloon catheter (figure 1b). The catheter is carefully introduced transcervically using a vaginal speculum and gently inserted so the tip of the catheter lies within the cervical canal or lower uterine cavity. Approx. 1 – 2 ml of saline is then used to inflate the balloon in order to fix the position of the catheter and prevent backflow of saline solution.

Normal saline is slowly injected and distension of the uterine cavity visualised under real time TVS control. Typically 10 – 20 ml of saline is required for most examinations. Injection of saline is halted at selected stages, dependent upon the degree of cavity dilatation and/or the area or structure to be examined, and a 3D volume acquisition or ultrasound sweep is carried out. The multiplanar image obtained (figure 2a) is reviewed and, if adequate, stored on to the system hard-drive. The procedure is then continued.

Fig. 2e: Surface rendered coronal anatomical section. The images collectively demonstrate normal uterine cavity (Cv) size and shape with an endometrial polyp (P) located within the mid-lower cavity. The catheter balloon (B) and catheter stem (C) (shadow) can be clearly identified.

It is crucial that the 3D system functions are easy to use with very rapid acquisition, storage and retrieval of ultrasound data. In addition, it should be stressed that the image quality achieved totally reflects the basic 2D (grey scale) performance of the ultrasound unit and correct utilisation of both 2D and 3D controls and presets.

On completion of the procedure, the acquired 3D ultrasound information can then be retrieved and manipulated at leisure and anatomical and clinical findings closely evaluated. Modern 3D ultrasound systems offer a range of image formats (figures 2a – 2e). This not only aids diagnosis itself but also greatly assists in terms of clinical communication of SIS findings. Manipulation of the surface rendering reference plane at both pre- and post storage stages is of significant practical importance (Clinical Case 1: figures d and e).

Clinical applications

Using saline infusion technique to separate and open up the walls of the uterine cavity enables high definition examination of its internal contour and clear delineation of intracavital lesions to be carried out. In addition, it allows detailed ultrasound evaluation of the peri-ovulatory endometrium and assessment of associated pathologies. As a result, SIS is now regarded in leading units as a routine, preliminary procedure used for investigating the cause of abnormal uterine bleeding. It is commonly carried out where standard TVS ultrasound suggests intracavital pathology exists both in referrals presenting with atypical pv bleeding as well as asymptomatic cases.

More recent clinical application involves the use of SIS as part of the preliminary investigation of female infertility. SIS is very effective in excluding or confirming the existence of relevant anatomical malformations of the uterus as well as intracavital/endometrial disorders. It is now common practice to include SIS as a pre-requisite to IVF in order to ensure the physical environment into which the resulting embryo is inserted is normal and healthy. Its clinical role extends into other areas of reproductive medicine and in major units it is now established as a key element in the investigation of recurrent miscarriage. Again, the procedure readily identifies anatomical and other gynaecological issues involving the uterine cavity and associated with increasing risk of early pregnancy failure.

Clinical Case 1 (Fig. a – e): The patient presented with abnormal uterine bleeding and a known history of uterine fibroids.

Clinical Case 1

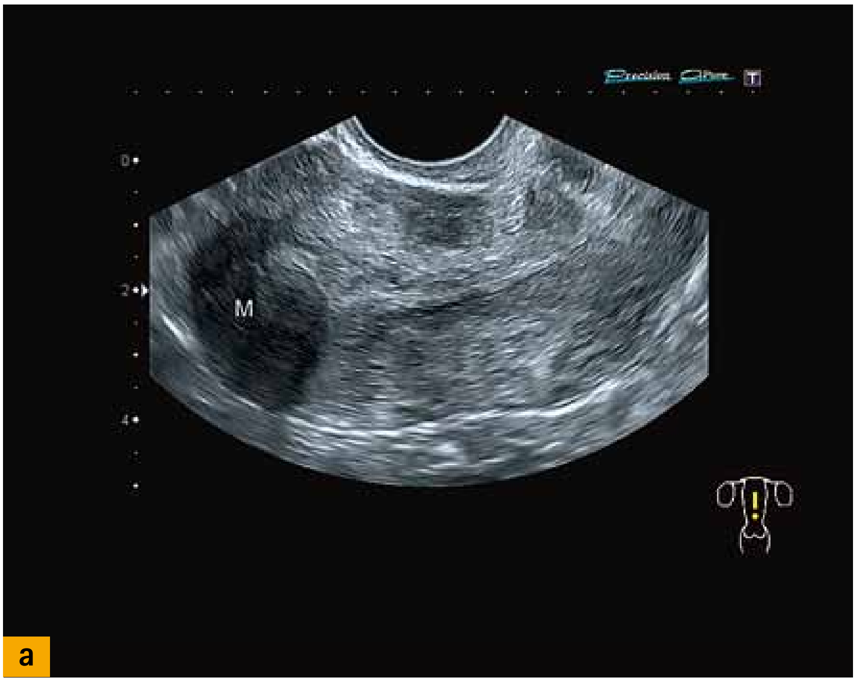


Fig. a: The initial standard 2D TVS (parasagittal) section shows an obvious fundal fibroid (M) encroaching on the upper uterine cavity. The endometrium appears irregular in texture but otherwise unremarkable. The uterine cavity appears uniform and normal on routine TVS examination.

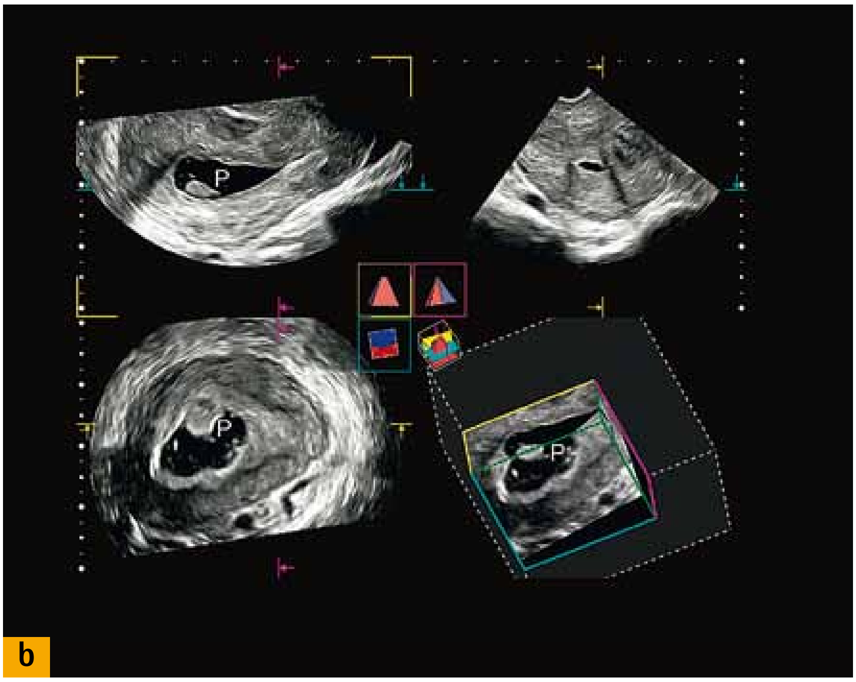


Figure b: Multiplanar reconstruction + block volume 3D images show irregular endometrial thickening with an obvious endometrial polyp (P).

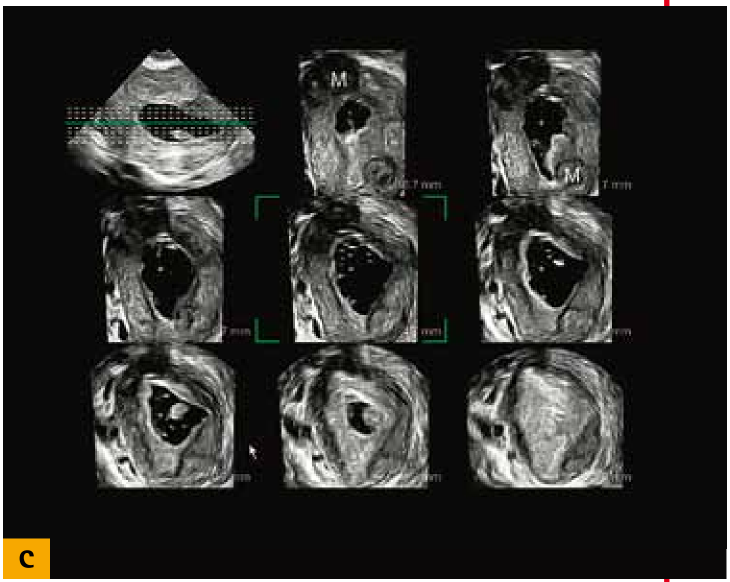
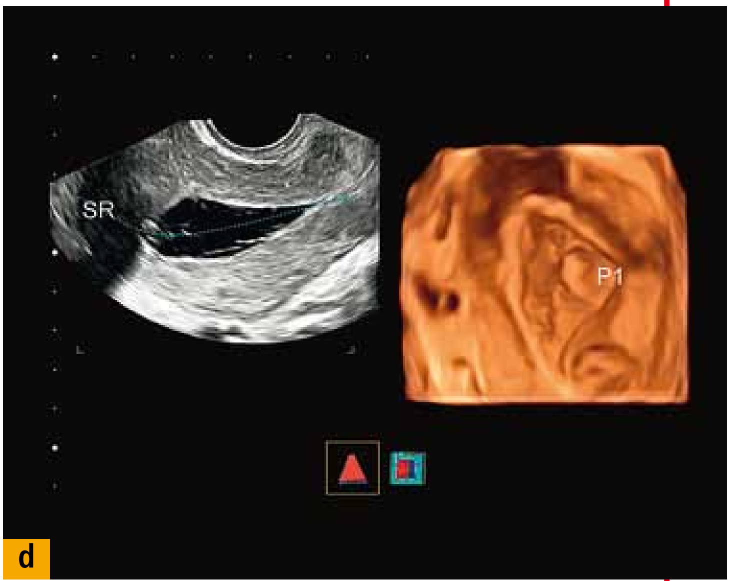


Fig. c: Multi View (tomographic) reconstruction (coronal 2D sections) confirm the findings suggested in figure b but also show that uterine fibroids (M) encroach upon but do not distort the cavity wall to any significant degree.



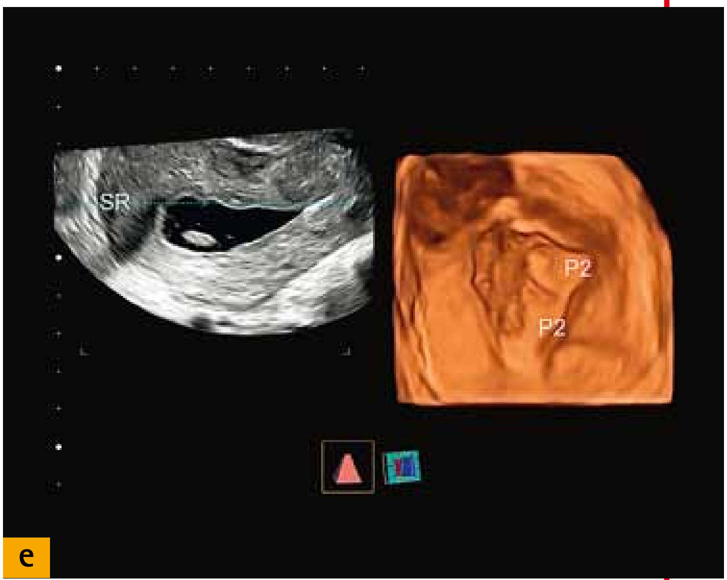


Fig. d + e: The two composite (parasagittal 2D + coronal surface rendered) images show not just a single pedunculated endometrial polyp (P1) but several further broad-base polyps (P2). Note the different anatomical sections obtained in figures d + e as a result of varying the surface rendering reference plane (SR).

Clinical Case 2 (Fig. a – e): The patient presented for HSS (hysterosonosalpingiography) assessment of the Fallopian tubes – the examination routinely includes an SIS evaluation of the uterine cavity. The patient was attending as part of preliminary investigation for secondary infertility with no known gynaecological history of uterine fibroids.

Clinical Case 2

Fig. a: The initial standard 2D TVS (parasagittal) section shows normal uterine size and shape for age and parity with no obvious myometrial lesion(s). Nevertheless there appears to be a thickened, irregular endometrial texture.

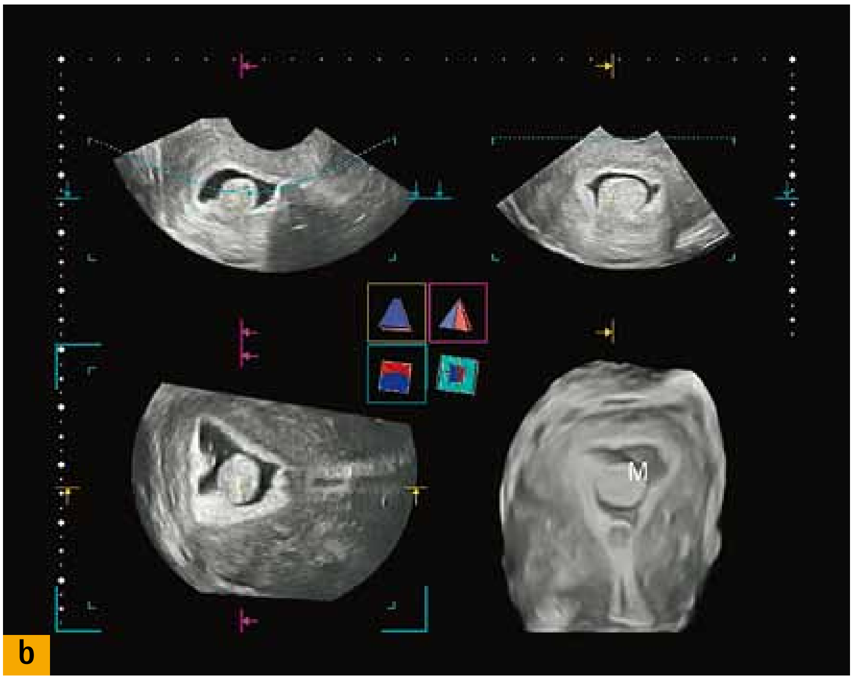
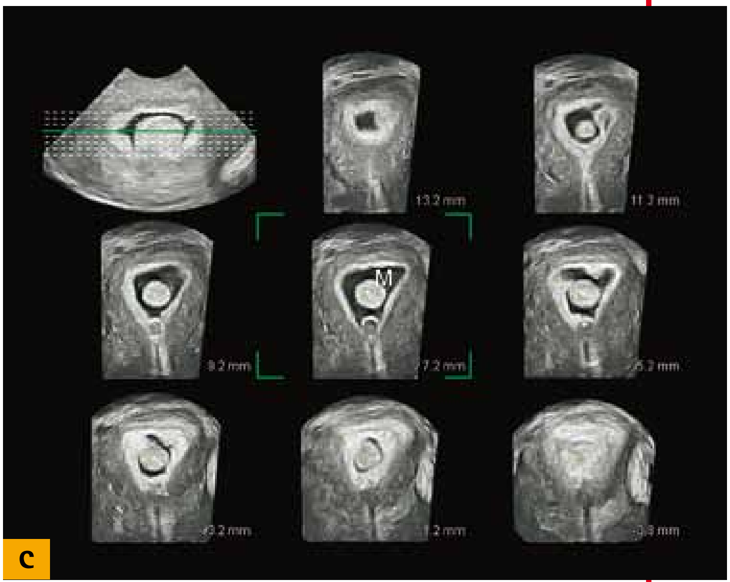
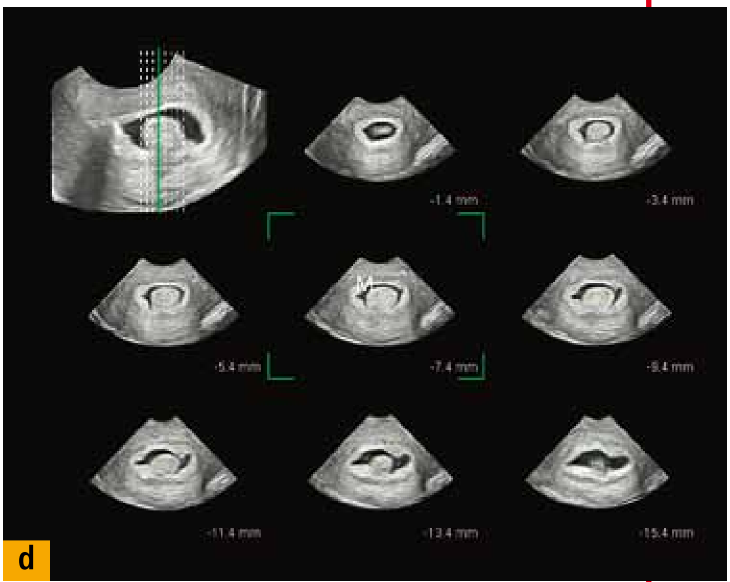


Figure b: Multiplanar reconstruction + surface rendered images delineate a very obvious intracavital fibroid (M) later confirmed at surgery.





Figures c + d: Multi View (tomographic) reconstruction (parasagittal + tranverse 2D sections respectively) again clearly outline the fibroid (M). The latter shows a broad-base attachment of the lesion to the cavity wall.

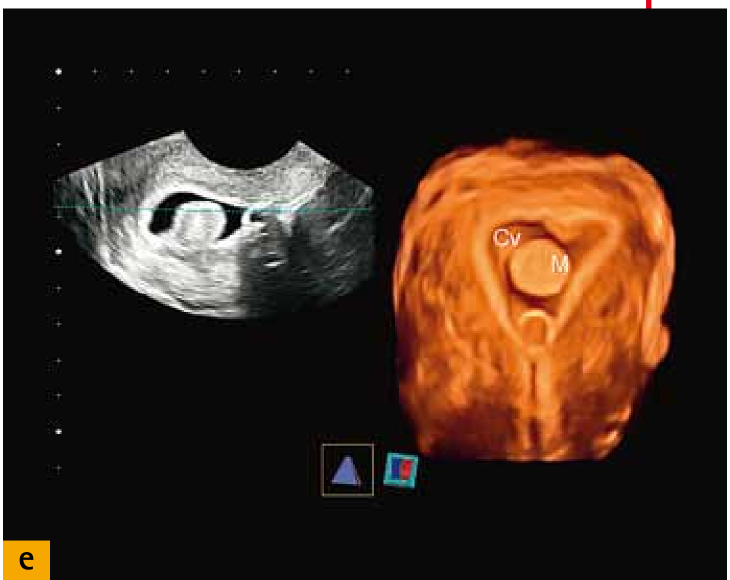


Figure e: Composite (parasagittal 2D + surface rendered) images offer very preciseimaging of the presence, size and location of the fibroid (M) within an otherwise normal uterine cavity (Cv).

Clinical Case 3 (Fig.a – e): Fly Thru technology. SIS examination for abnormal uterine bleeding.

Clinical Case 3

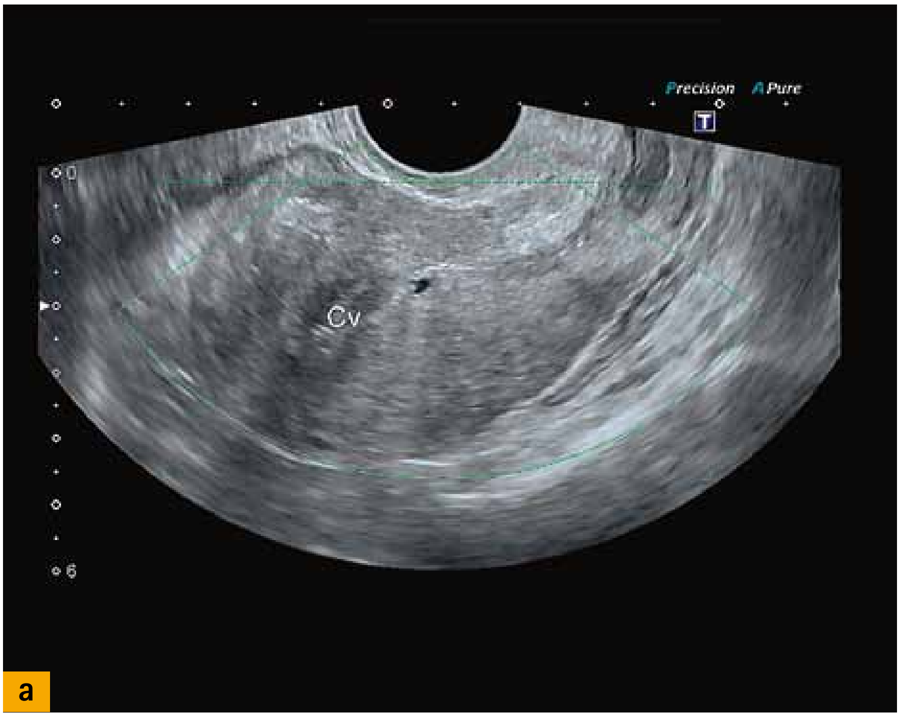


Fig. a: Displays a standard 2D TVS (parasagittal) section of the uterus and uterine cavity with an obvious irregularity within the mid-upper cavity (Cv).

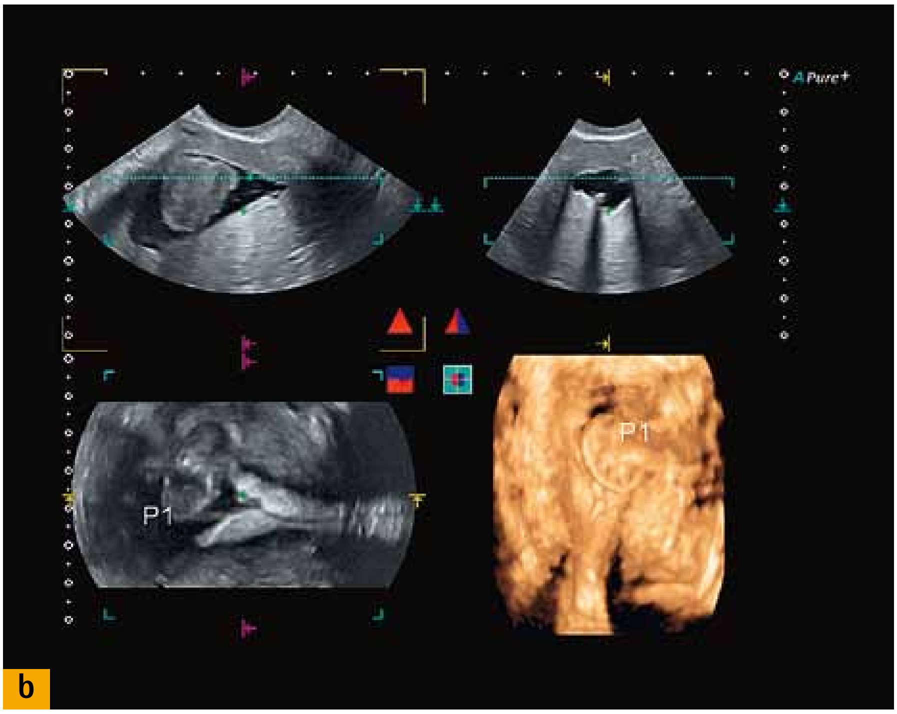
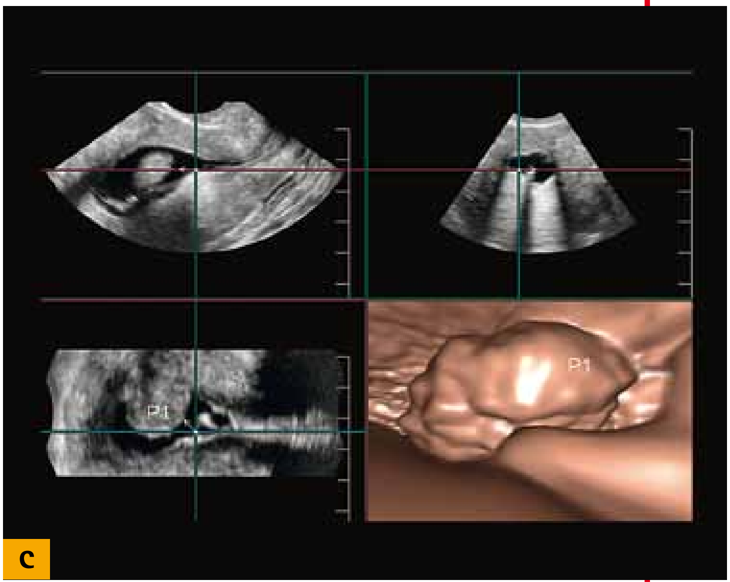
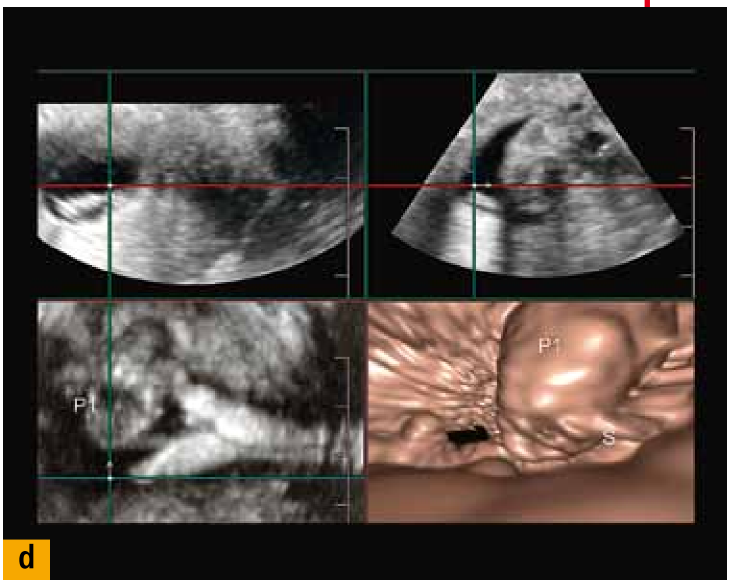
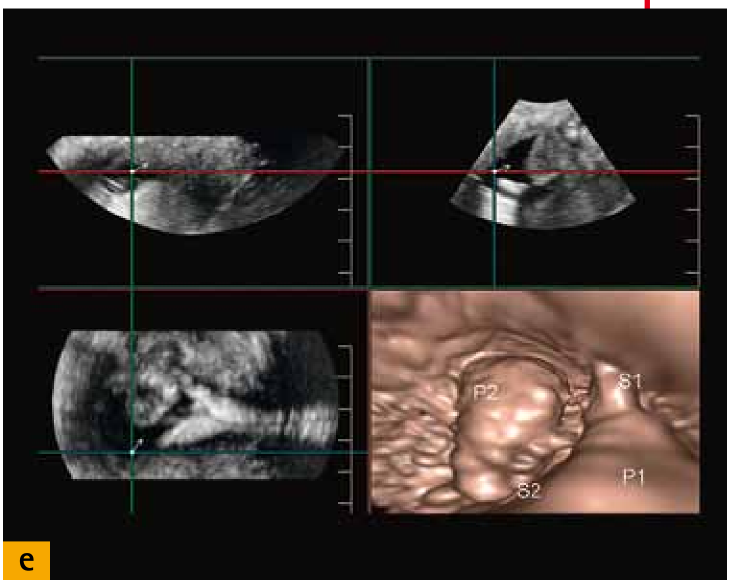


Figure b: Multiplanar reconstruction (x, y, z component) plus rendered (coronal) image. The images clearly demonstrate a large endometrial polyp (P1).



Figures c: Multiplanar reconstructions with Fly Thru displays showing a large polyp (P1) from different directions.





Figures d–e: Multi-planar reconstructions with Fly Thru displays showing a large polyp (P1) from different directions. Figure d clearly delineates the polyp pedicle (S1). The Fly Thru display in figure e delineates a further, smaller polyp (P2) of only a few milli-metres in size adjacent to the polyp (P1).

Ultrasound hysterography: Fly Thru technology

The potential of 3D/4D TVS saline infusion sonohysterography to create an acceptable alternative to diagnostic hysteroscopy appears to be a realistic option as a result of very recent advances in Toshiba's Aplio ultrasound system. The Toshiba Leading Innovation programme has produced the Fly Thru imaging process.

Fly Thru technology uses the raw data obtained from a single 3D volume data set and creates cross-sectional ultrasound imaging which produces a visual display comparable to virtual reality endoscopy (Figure 3). The facility allows either manual or automatic navigation through the uterine cavity once it has been distended by saline solution. The internal contour, or any intracavital lesion present, can then be visually assessed, unlike in the case of diagnostic hysteroscopy, from any direction.

The high quality images, produced from a single 3D volume acquired by the system, provide greater anatomical detail of the internal features of the uterine cavity and improved delineation of associated lesions using Fly Thru. It confirms with greater certainty those cases which need to be referred on for surgical (endoscopic) investigation and management.

The most common cause by far of abnormal uterine bleeding, even in post-menopausal patients, is functional in nature and invariably involves atypical ovarian activity. Fly Thru appears to have a potentially crucial role in excluding intracavital pathology and providing greater diagnostic confidence leading to more conservative clinical management in the majority of those patients.

Summary

- 3D TVS saline infusion sonohysterography is now an integral part of gynaecological ultrasound examination.
- Its diagnostic value and clinical impact in general gynaecological assessment principally involves the investigation of abnormal uterine bleeding. In addition it has a crucial role in aspects of fertility managements as well as investigation of recurrent miscarriage.
- The technical and clinical effectiveness of SIS procedure depends on the availability of modern, high quality 3D (volumetric) ultrasound facilities.
- In leading units, SIS has replaced diagnostic hysteroscopy with considerable benefits encompassing practical, diagnostic and financial aspects as well as levels of patient acceptability.
- Advanced innovations in Toshiba ultrasound technology has resulted in the development and practical utilisation of 4D Fly Thru imaging. The visual impact and diagnostic capability it offers gives considerable credence to the concept of ultrasound hysteroscopy with obvious clinical benefits.

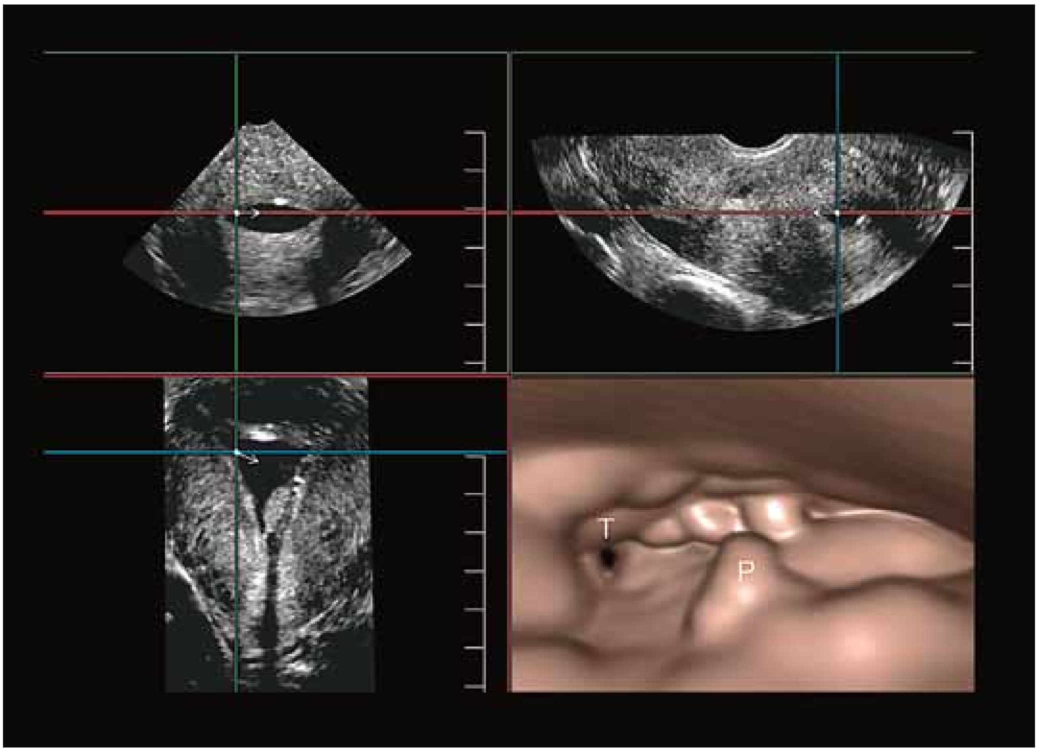


Figure 3: Fly Thru technology. A multiplanar (x, y, z components) plus Fly Thru display. An endometrial polyp (P) can be seen very clearly on the Fly Thru image as well as endometrial folds plus the Rt internal tubal ostium (T). The Fly Thru image is comparable to hysteroscopic visualisation of the relevant structures. Furthermore, navigation through the uterine cavity could be carried out either manually or automatically by the system itself.

A different dose race

In March, Toshiba presented their innovative dose reduction technologies to 21 leading Spanish physicists. While dose reduction is no doubt an exciting issue we wanted to offer our guests some extra bpm. And since serious horsepower is a great way to boost your heart rate we combined the professional programme with a driving seminar on the famous Jarama circuit outside of Madrid.

The scientific programme encompassed three presentations: Dr Pablo Gómez Llorente talked about his quality control checks that take him all over Spain. He underlined that after installation of an imaging system the manufacturers in general have no further control over the actual usage of the technology. They can provide their best tools but in the end it is the radiologist who decides when and how to use them. Dr Gómez therefore suggested to intensify the collaboration between radiologists, physicists and manufacturers.

Then Dr Jacob Geleijns presented the Toshiba technologies to reduce dose in cardiac CT applications. His – as usual – very well documented material was received with great interest. He answered several questions from Dr España and Dr Fernández of H. Princesa in Madrid and HUCA in Oviedo who were very critical about dose in recent public tenders. Dr Geleijns answers dispelled their doubts.

In the third presentation Roy Irwan focused on recent dose reduction developments such as AIDR or active collimation. He answered questions from Dr H Armas of HUC in Tenerife and others.

In a closing statement, Israel López outlined Toshiba Spain's plans to introduce low dose and paediatrics protocols at their multi-slice installed base and to improve user training.

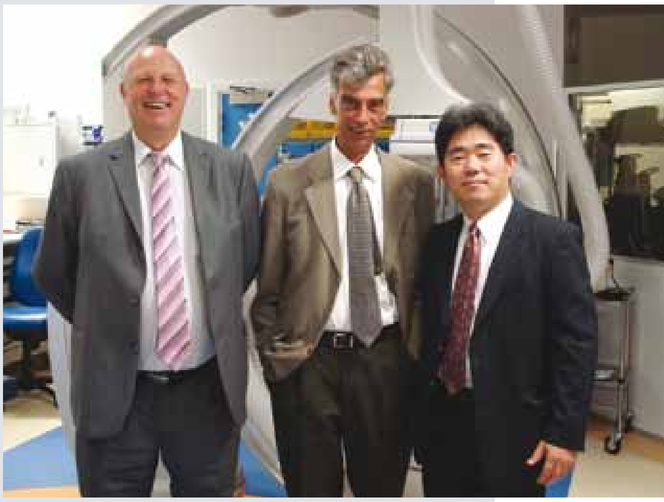
Then it was time to take the drivers' seat. After an introduction by the pilots the "hands on the steering wheel" part began. Everyone participated, everyone loved it - and everybody loved the buffet that followed the driving instructions. To close a wonderful day, all participants received a diploma and the winners were awarded a prize.

Gorilla gets heart checkup with Xario XG

"Jomo," the Cincinnati Zoo & Botanical Garden's 19-year-old silverback western lowland gorilla, got a heart checkup as part of a preventative study. A team of cardiologists, technicians and corporate partners made the house call to the Cincinnati Zoo's Gorilla World exhibit recently to perform an awake cardiac ultrasound (also known as an echocardiogram or an echo) on Jomo. As in humans, an echo is critical for assessing heart condition and identifying any problems. With early detection, follow-up treatments can be prescribed. To date, heart disease is the #1 cause of mortality in zoo gorillas. Jomo received a clean bill of health, and the zoo was able to collect valuable cardiac data that will aid nationwide scientific research.

New cardiac biplane system for children's care

At Birmingham Children's Hospital (BCH), one of the leading pediatric hospitals in Europe, a Toshiba cardiac biplane system has been in operation since April this year. Dr. Oliver Stumper, a pediatric cardiologist at the hospital, is highly satisfied with using the system. In addition, from September, a hybrid OR with a Toshiba C-arm system will be installed in the next room.



From left: Mark Holmshaw (Senior Manager of X-ray Business Unit, TMSE), Dr. Oliver Stumper (Birmingham Children's Hospital), and Mr. Yamamoto (General Manager, X-ray Systems Division, TMSC)

Toshiba finalizes the acquisition of Vital Images

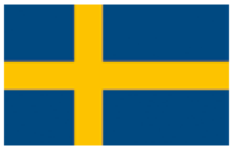
Toshiba Medical Systems Corporation (TMSC) and Vital Images, Inc. announced that they have entered into a definitive agreement pursuant to which "Merger Sub", a subsidiary of TMSC, will acquire all of the outstanding shares of common stock of Vital Images for $18.75 per share. Vital Images, Inc. is a leading provider of advanced visualization and analysis software for physicians and healthcare specialists. The company's software provides users productivity and communication tools to improve patient care that can be accessed throughout the enterprise anytime, anywhere via the Web.

Michael Carrel, CEO of Vital Images, stated: "TMSC has been our largest customer for a decade, as well as a strategic development partner. We will combine forces to enhance the multi-modality platform we have been marketing to hospitals in the U.S. and overseas. This transaction means we can now accelerate our global presence with the strength and backing of TMSC."

And Satoshi Tsunakawa, chief executive officer of TMSC, added: "After a decade-long successful partnership spanning more than 50 countries, TMSC is taking the partnership to the next level. We have enormous respect for Vital Images' products, pipeline and people, and look forward to working with their highly skilled team to enhance clinical value for patients throughout the world. This transaction will allow TMSC to significantly strengthen its Imaging Solutions business by integrating our technologies to meet the global demand for advanced visualization and imaging informatics provided to healthcare professionals and through healthcare IT providers."

VITAL TOSHIBA

Toshiba goes Sweden



Toshiba will establish its own sales and service organisation in Sweden and assume direct responsibility for both the commercial representation and technical support of the Toshiba portfolio.

Sweden is very important and significant in terms of the quality of its healthcare delivery system and the technology that it requires to provide diagnostic and therapeutic services at the most advanced level. It thus was a logical decision for Toshiba Medical Systems Corporation, which is a major player in the development and introduction of new and innovative technology on a global basis, to get into direct contact with the market place and to convey to customers in Sweden its very serious commitment to the Swedish market. Toshiba plans a high level of investment in Sweden to ensure the necessary resources are readily available to support customers at every level.

All aspects of this transition are moving forward with the optimum level of cooperation, the mutual goal being to ensure that customer service is maintained at an optimum level.

Maura Malpighi (The Basket of Cherries) and Paolo Ruta (Toshiba Ultrasound Application Specialist)

Modena breast cancer prevention with Toshiba ultrasound

The non-profit organisation "The Basket of Cherries" headed by Maura Malpighi, organised a promotional breast cancer prevention event in the city centre of Modena (Italy). During the day renowned oncologists and radiologists performed ultrasound scans using Toshiba's innovative breast imaging software on both Aplio MX and Viamo. All doctors involved, many of them based at the University Hospital of Modena, had the pleasure to work with what is considered the best in the market for diagnostic ultrasound imaging. They were very impressed by the image quality of the Viamo generated with the high frequency probes and confirmed the excellent performance of Aplio MX.

The importance of the event was highlighted by the visit of the mayor of Modena, the Councillor for Health for Emilia and several radiology and oncology professors. The event was endorsed by RADIO STAR and the daily newspaper La Gazzetta di Modena.

www.ilcestodiciliege.it

From left: Mr. Shigeta (general manager of Kyoto Branch Office), Mr. Yazaki (research assistant of CO2 Storage Research Group), Mr. Shiragaki (senior researcher of CO2 Storage Research Group), Mr. Shirase (Director of the Kansai Regional Office), Mr. Yoshimoto (Sales Promotion Department), and Mr. Yuzuriha (Kyoto Branch Office)

Aquilion helps to study global warming

An Aquilion ONE system has begun operation at the Research Institute of Innovative Technology for the Earth (RITE) in Kizugawa-shi, Kyoto. RITE has been working to solve issues related to global warming. A basic technical research institution for addressing global environmental problems such as climate change, RITE was jointly established in 1990 by local authorities and private companies.

The CO2 storage research group has developed fundamental technology for safely storing below ground (approximately 1000 m) CO2 that has been separated and collected from large emission sources such as thermal power stations. In order to evaluate the behavior of CO2, a sandstone sample is placed in a container in which pressures and temperatures equivalent to deep subterranean locations are reproduced. CO2 is injected into the container and the sandstone sample is scanned by Aquilion ONE. The RITE researchers were particularly impressed by Aquilion ONE's 4D scanning with 160-mm-wide area detector – a unique technology which is ideally suited for this very special task.

Researchers and business providers who are engaged in tackling global warming pay careful attention to the activities of RITE, and Aquilion ONE will play a full part in research undertaken to address global warming issues.

Mr. Honjo (senior director of RITE) and executives of RITE listen to an explanation from Mr. Yoshimoto (Sales Promotion Department).

PRIME quality and patient comfort – a perfect mixture

The Institute of Diagnostic and Interventional Radiology at Klinikum Darmstadt in Germany focuses on oncology, vascular medicine, neuro-radiology, traumatology and orthopaedic problems. An important task of the diagnostic radiologist is to define, for each investigation, the right combination of scanning time and radiation exposure that ensures best possible diagnostic quality. "The Aquilion PRIME provides optimal conditions to realize the safest patient examination", says Professor Huppert, the Institute's Director. "As far as patient comfort is concerned, I can say that it surpasses any of our previous CT scanners," Huppert added.

Prof. Dr. Peter Huppert (right) director of the Institute of Diagnostic and Interventional Radiology at Klinikum Darmstadt

Toshiba powers new electric vehicles from Mitsubishi

Toshiba Corporation's SCiB™ battery has been selected by Mitsubishi Motors Corporation to power two new models of electric vehicles (EV), the i-MiEV and MINICAB-MiEV. The SCiB is Toshiba's breakthrough rechargeable lithium-ion battery that combines high levels of safety with a long life, rapid charging and excellent charging and output at a wide range of temperatures.

The SCiB pushes the life of the lithium-ion battery to a new level by supporting 2.5 times more charge/discharge cycles than a typical lithium-ion battery. Recharging is also notably better. SCiB reaches about 80 percent of full capacity in some 15 minutes, about 50% in 10 minutes and about 25% in 5 minutes – half the times of a typical lithium-ion battery charged under the same conditions. The SCiB also generates little heat while recharging, eliminating the need for power to cool the battery module.

The battery offers a higher effective capacity than a typical lithium-ion battery, in that more of the stored charge can be used safely before recharging the battery. This, combined with highly efficient regenerative charging during braking or coasting downhill, allows the SCiB to deliver 1.7 times the driving distance per level of charge of a typical lithium-ion battery. This will allow for installation of smaller battery modules in vehicles and contribute to lower EV prices.

As the automotive industry responds to concerns about global warming by developing a new generation of environmentally friendly EV, Toshiba is promoting advances in essential automotive technologies, from dedicated on-board control systems to batteries and Intelligent Traffic Systems. In automotive-related power electronics technologies, Toshiba is targeting net sales of 800 billion yen by fiscal year 2015 from its concentration on motors, inverters and SCiB. Toshiba will continue to promote sales of the SCiB in a global market for lithium-ion batteries that is expected to record sales of some 1 trillion yen in fiscal year 2015.

For rent – The Secondlife CT trailer

Recently Toshiba's Secondlife Refurbished Equipment Division received a mobile CT trailer which is designed to meet a variety of requirements such as "emergency down" situations, planned replacement or expansion and much more.

Equipped with an Aquilion 16 CT scanner and a Viamo portable ultrasound system the unit represents an advanced mobile imaging center that delivers unprecedented power, flexibility and diagnostic possibilities.

The Aquilion 16 can acquire sixteen 0.5 mm isotropic slices with each 0.5 second revolution, so a volumetric map of the patient can be created in a single exam. This unique capability enables physicians to make multiple diagnoses from a single data set.

The Viamo combines all the advantages of a portable ultrasound system with the diagnostic precision, productivity and comfort of a premium cart-based machine. Sharing its core imaging engine and transducer technology with the Aplio series, Viamo offers uncompromised image quality and clinical workflow support in situations where unlimited portability is required.

The hydraulic patient lift ensures safety and convenience for staff and patients alike. The interior is built to suit the radiologists, radiographers and patients. For the privacy of patients two cubicles are available, accessible via easy to use stairs at the backside of the trailer. The control room offers the radiographers a spacious working environment.

The Secondlife mobile CT trailer can be rented from one week up to five years or even longer.

Running for cancer patients

The Roparun has one simple goal: collect as much money as possible for patients with cancer. Not to support research, but to make life a bit more pleasant for these patients and their families. "Add quality of life to the days, if you can't add days to life" is the theme of Roparun.

275 teams, each consisting out of 8 runners, at least 4 bikers and 2 masseurs – accompanied by many other supporters – appeared at the start of the Roparun. Carla Witkam, Clinical Application Specialist, Ultrasound Business Group, was one of the 2200 runners. In relay she and her 7 team members covered the 520 km from Paris to Rotterdam in 45h 58m 33s. Every runner did about 65 km with an average speed of 11.32 km/h. As a good Corporate Citizen of planet Earth, Toshiba was happy to sponsor Carla's team with an amount of € 1.200.

"At the tough moments during this run in the hills and darkness when you get tired after to little sleep, you just think of someone in your environment with cancer. Of course you are running for all patients with cancer, but I did it especially for my friend who has a Type-4 brain tumor. I'm so proud of the way she is dealing with this terrible disease," says Carla. "She was in my mind all the time because her fight against cancer is much tougher then me running in the hills after not enough sleep."

Carla Witkam and Team at Finish

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Vantage Titan 3T

Experience 3T like never before!

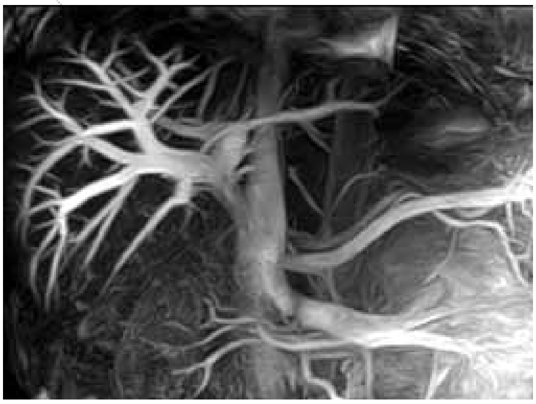

Image of high resolution liver MRA without contrast agent acquired with Toshiba's Vantage Titan 3T

Toshiba's new Vantage Titan 3T sets new standards in Comfort, Imaging and Productivity:

- Comfort
  - The widest with a unique combination of a short 1.6 meter magnet and a large 71 cm opening
  - The quietest with Toshiba's Unique "Pianissimo" technology
- Imaging
  - Excellent Magnetic (B_0) and RF Field (B_1) Homogeneity
  - From head to toe without shading
- Workflow
  - Fast and easy operation by the Atlas matrix coil system
  - Equipped with M-power; a new cross-Modality software platform

Made for Life™

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ULTRASOUND CT MRI X-RAY SERVICES

Initial Clinical Experience with the Toshiba 3T MRI

Focuses on the Cardiovascular System

T. Nitatori

Our hospital has been operating its first Toshiba Vantage Titan 3T MRI in clinical practice since September 1st 2010. The Titan 3T is characterized by its wide open bore. The 71cm bore alleviates claustrophobia even in large patients, making an examination easier to facilitate. Greater space in the bore between the patient and the gantry is more suitable for emergency patients, patients encumbered with monitoring equipment, and patients unable to lie in the supine position. The Titan 3T also incorporates Toshiba's unique Pianissimo silencing technology which keeps the operating noise level equivalent to the 1.5T MRI. Multi-phase Transmission, the world's currently highest specification with two channel and four port power supply, effectively reduces image irregularities even in chest and abdomen. This seminar describes the clinical efficacy of the Titan 3T, primarily for cardiovascular region.

3T MRI technical characteristics and multi-phase transmission

There are 2 basic principles that determine to which extent the NMR signal is amplified in a 3T MRI; one is the magnetization vector, which is proportional to the static magnetic field strength, while the other is the induced current in the receiver coils, which is proportional to the frequency. Since the electromotive force generated when the magnetic field cuts across a coil is proportional to the change in the magnetic field over time, the resonance frequency for 3T MRI (128MHz), is twice the frequency of the 1.5T. Furthermore, the signal strength is proportional to the square of the static magnetic field strength. Consequently, the signal strength for 3T MRI has a maximum theoretical value of four times the value obtained with a 1.5T.

However, as the static magnetic field strength increases, the signal-to-noise ratio is reduced by the following factors:

- thermal noise from the body of the patient,
- system noise generated by the equipment electrical circuits,
- noise generated by the difference between the spin frequency and resonance frequency due to magnetic susceptibility and chemical shift effects, and
- extension of T1 relaxation time due to increased resonance frequency, with consequent reduced signal strength which delays recovery of longitudinal magnetization.

Due to all these factors the signal-to-noise ratio for 3T MRI is therefore limited to approximately twice that with a 1.5T.

There is also a significant problem with 3T MRI from increased RF irregularities. Since its release, therefore, the efficacy of 3T MRI has been greater for the head area while application to the abdominal area and cardiovascular organs has proved to be difficult. Efforts by the manufacturers to resolve

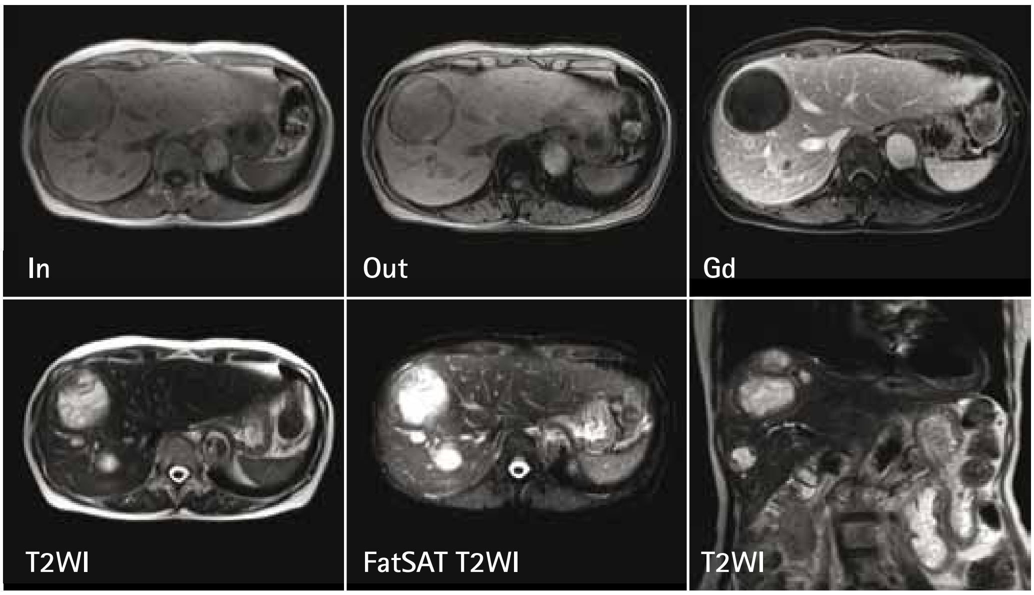


Fig. 1: Liver metastases in patient with a history of breast cancer

*Toshiaki Nitatori, M.D.
Professor & Chairman,
Department
of Radiology,
Kyorin University,
Faculty of Medicine*

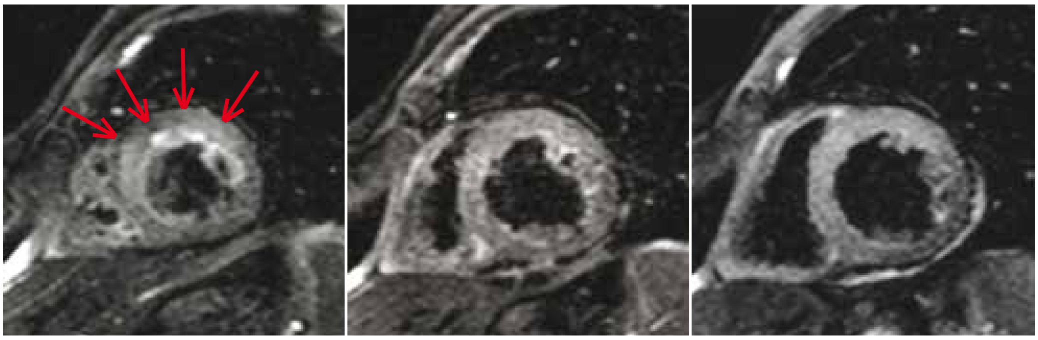


Fig. 2: FSE T2 weighted Black Blood images with FatSat on a 60 y/o male with acute myocardial infarction. Improvement in the SNR and CNR for normal myocardium and myocardium with edema are demonstrated

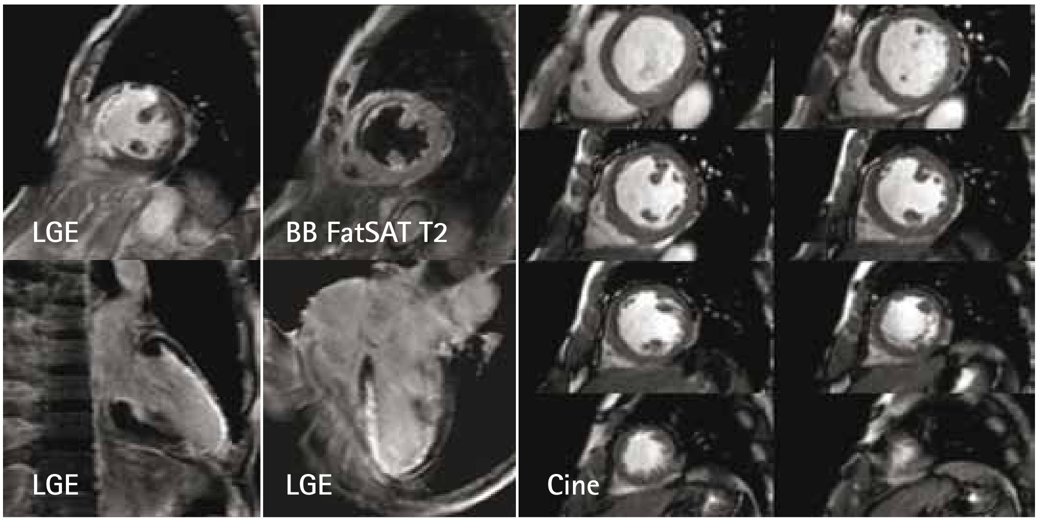


Fig. 3: Cardiac MRI1

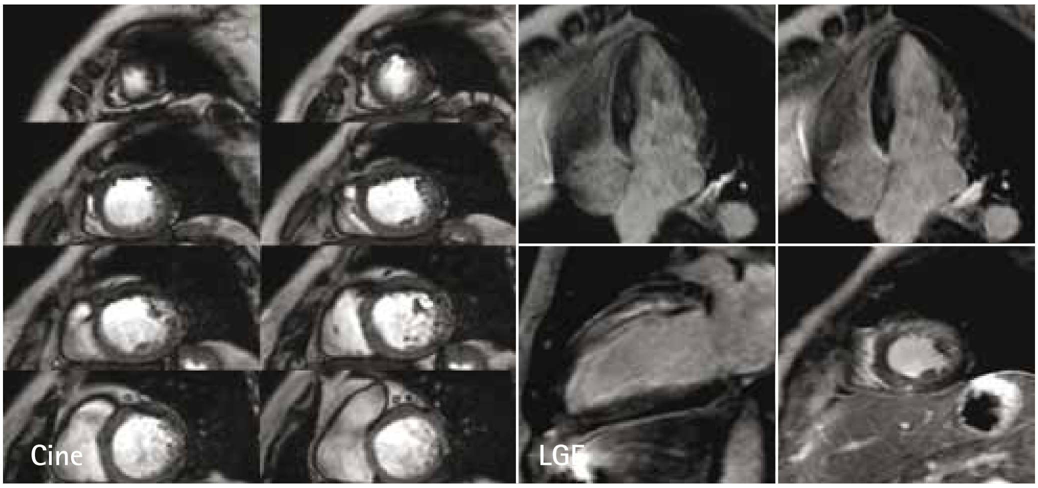


Fig. 4: Cardiac MRI2

this problem have led to the development of Multi-phase Transmission technology. Multi-phase Transmission ensures uniform RF strength distribution, and reduced image irregularities. Toshiba Medical Systems' 3T equipment is the first of its type in Japan, and currently has the world's highest specification, with two RF amplifier and a four-port power supply. In the Titan 3T, this technology produces images with strongly reduced RF irregularities and facilitates its expanded application in the upper abdominal area and chest region, previously a problem with 3T MRI (Fig. 1).

Initial clinical experience of the TITAN 3T in the cardiovascular region

With 3T MRI, the heart suffers from susceptibility artefacts and SAR (Specific Absorption Rate) restrictions, which has proven to make imaging this area difficult in the past. With the earlier described Multi Phase transmission technique the Titan 3T, however, produces very clear images (Fig. 2-5).

True SSFP is the primary method used with the 1.5T, but static and RF magnetic field irregularities, as well as SAR restrictions, have made it difficult to use

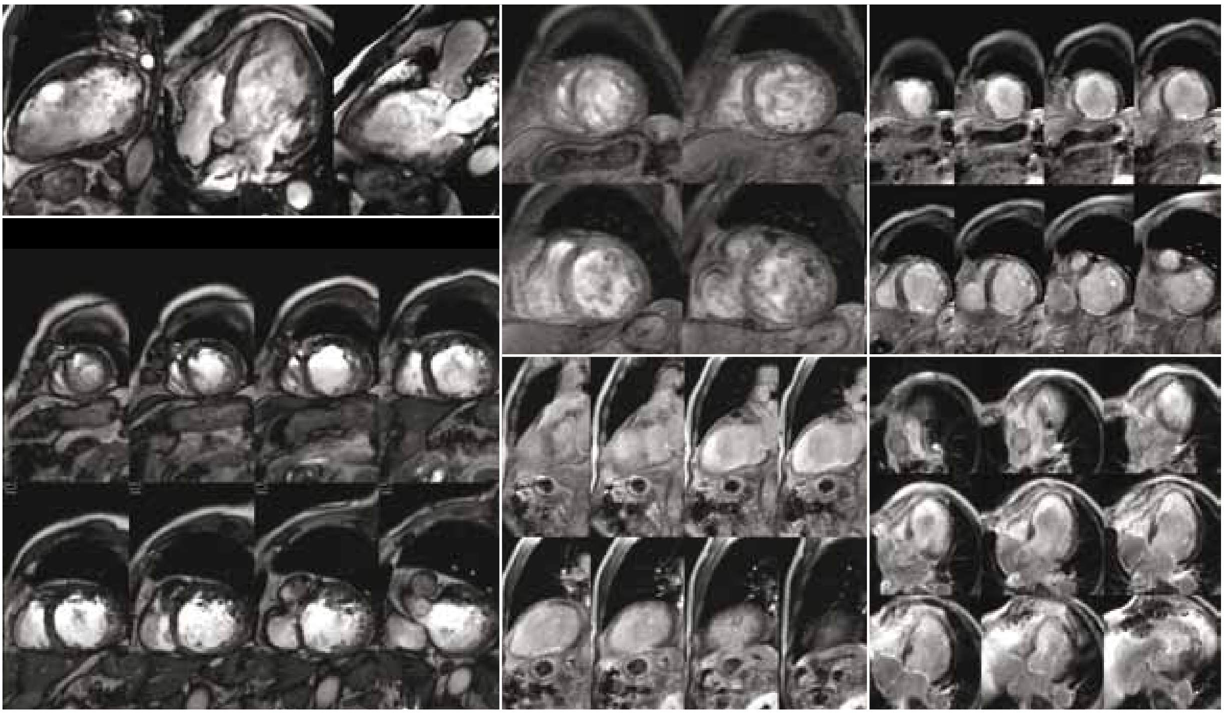


Fig. 5: Cardiac MRI on a patient with elevated heart rate of 87bpm

this technique for 3T cardiac MRI. Susceptibility artefacts and banding artefacts are particularly noticeable in cine MRI with 3T equipment (Fig. 6) .

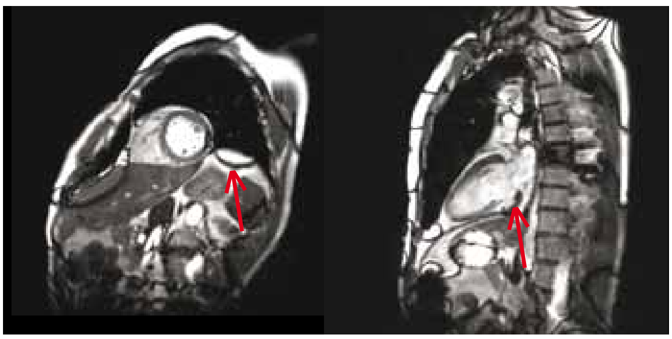
Artefacts were therefore suppressed by shifting the center frequency (f_0). Changing the center frequency from 0 ppm, to 1.0 ppm and to 1.5 ppm resulted in a shifting of banding artefacts on the screen as shown in Fig. 7. The area of interest to image the heart is narrow and shifting banding artefacts to other areas ensures a satisfactory image as shown in Fig. 8, however, there is still room for improvement.

Due to irregularities in the local magnetic field, the use of TrueSSFP in cardiac muscle perfusion MRI, results in pseudo defects, with consequent image quality deterioration. Therefore IR-FFE is used instead. On the other hand, extension of the tissue TI relaxation time has the major advantage of extending the duration of tags with the tagging method (Fig. 9).

Use of 3T high signal-to-noise ratio in thin slicing

The most significant characteristic of 3T equipment in cardiac MRI is the ability to use the high signal-to-noise ratio in thin slicing. Thin slice imaging was not practical with

Fig. 6: Cine MRI on 3T (normal volunteer) demonstrating susceptibility and banding artefacts TR/TE=4.2/2.1, FA 46



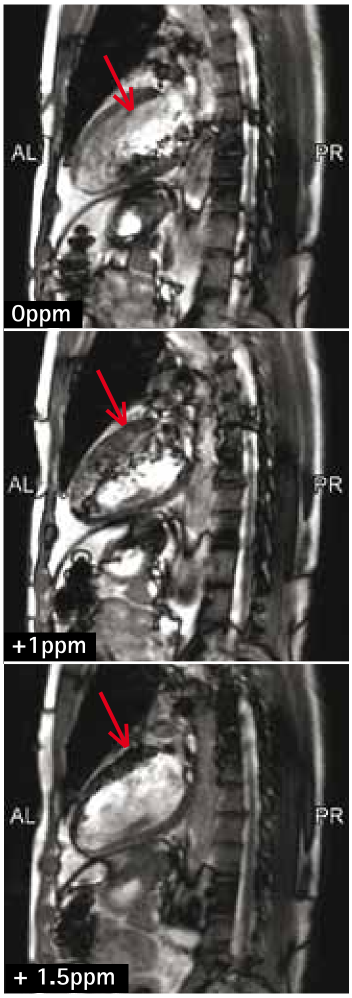


Fig. 7: Prevention of banding artefact

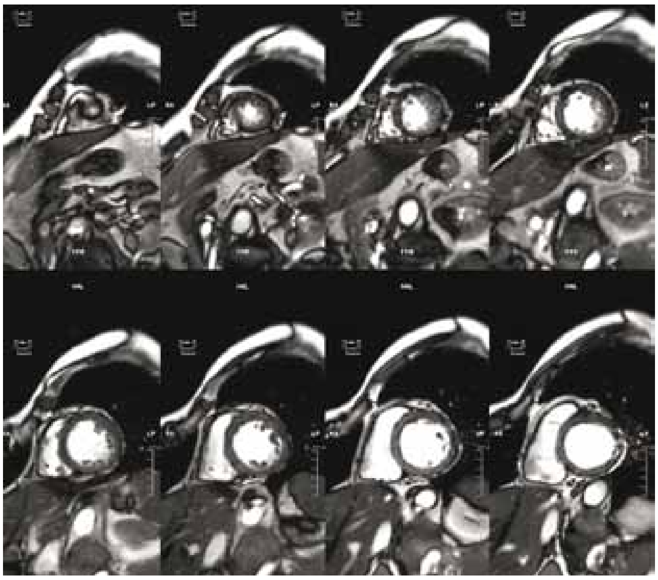


Fig. 8: Cine MRI (SSFP) old myocardial infarction
TR/TE=3.4/1.7, FA42.

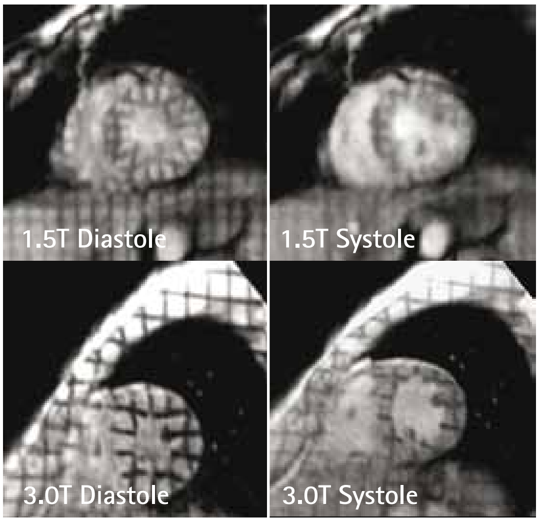


Fig. 9: Tagging method comparison between 1,5T and 3T. Tagging label is sustained over time because of extended TI relaxation time on 3T

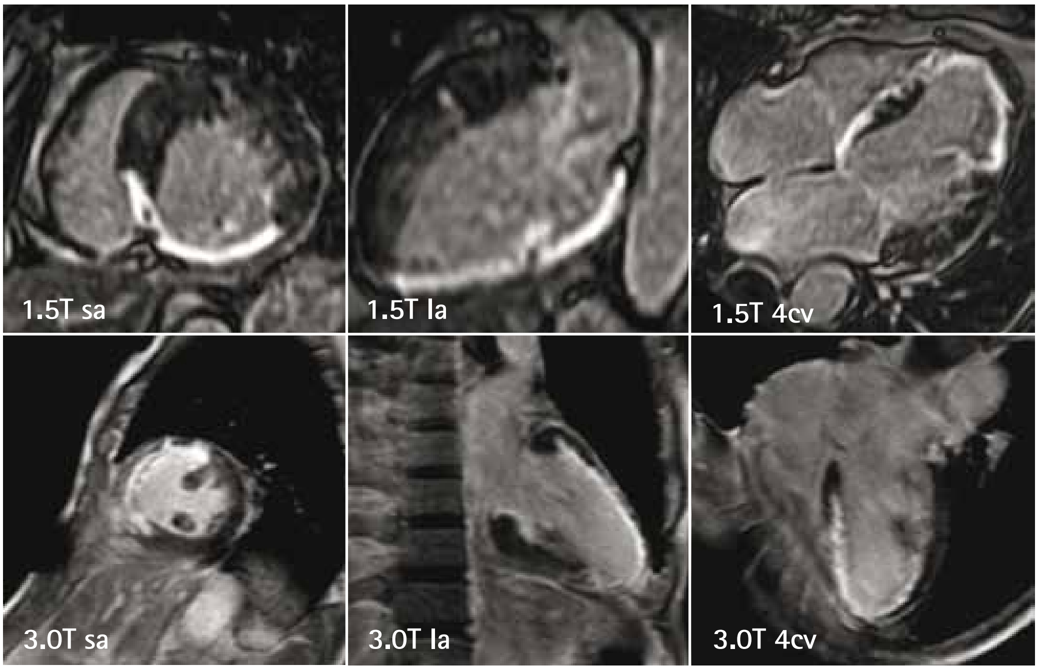
1.5T equipment, however it is now used aggressively with 3T MRI. The advantage of thin slice imaging lies in the ability to use whole heart late gadolinium enhancement for delayed cardiac contrast MRI.

The heart is imaged in thin slices as with multislice CT imaging; these images are assembled together to produce a variety of images (e.g. short and long axis, and four-chamber views) for evaluation. With 1.5T equipment, the acquired slice thickness was 3mm and reduced to 1.5 mm with interpolated reconstruction, however 3T MRI permits a slice thickness of 1.5 mm or 0.75 mm, providing images with high spatial resolution (Fig.10).

Summary

This seminar has described our initial clinical experience with the Titan 3T, primarily in the cardiovascular field. I would like to take this opportunity to express my thanks and respect to the technical personnel who strives to improve the system's technical performance.

Fig. 10: Whole heart late gadolinium enhancement, short axis, long axis and 4 chamber view of 1.5T and 3T respectively



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Tumor Fed by Femoral Artery

Radiology demands speed, precision and optimum performance. Toshiba designed the Infinix VF-i to meet these requirements by taking advantage of the very latest technological innovations, dramatically reducing procedure time and risk during catheterization.

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ULTRASOUND CT MRI X-RAY SERVICES

Smaller detector and housing prove a big advantage in cardiology

Toshiba's Infinix VF-i/SP in the angio intervention lab at Gelre Hospital, Zutphen

Dr Jeroen de Jong:

"It is a unique product in Europe –

the only system available with a 30 x 30 cm FPD and extra small FPD housing."

Jeroen de Jong, MD
Cardiologist
Gelre Ziekenhuizen
Den Elterweg 77
7207 AE Zutphen
The Netherlands

First Toshiba Infinix VF-i/SP 30 x 30 cm Flat Panel Detector installed in Europe

In our last issue of VISIONS, we had a look at how radiologists at Gelre Hospital in Zutphen, the Netherlands, benefit from the enhanced versatility and superior image quality of the new Infinix VF-i/SP Shared Cardiac and Vascular Lab with 30 x 30 cm Flat Panel Detector (FPD) and extra small FPD housing.

For this issue, we took another trip to the hospital to see how the first system installed in Europe is helping cardiologists such as Dr Jeroen de Jong expand the scope of their work and provide significant improvements in patient handling and throughput.

VISIONS: *Would you briefly describe Gelre Hospital?*

Dr de Jong: Gelre Hospital consists of several hospitals and clinics that jointly serve the towns of Zutphen, Apeldoorn, Epe and Lochem in the province of Gelderland in the Netherlands. I treat patients from both the Zutphen and Lochem facilities.

Gelre Hospital Zutphen now operates from a new building which was opened in October 2010. It encompasses a state-of-the-art Cath Lab in whose planning and development I was closely involved. The Cath Lab is equipped with a Toshiba Infinix VF-i/SP Shared Cardiac and Vascular Lab with 30 x 30 cm FPD that was installed in the autumn of last year and was operational for the opening of the new hospital.

VISIONS: *How did you arrive at the decision to purchase Toshiba's Infinix VF-i/SP Shared Cardiac and Vascular Lab with 30 x 30 cm FPD?*

Dr de Jong: Choosing this system was an easy decision. It is a unique product in Europe - the only system available with a 30 x 30 cm FPD and extra small FPD housing. Toshiba have really listened to their customers' needs when developing this product. It is large enough for high quality vascular imaging and able to perform the required steep angulations for cardiac imaging. Cardiologists in Europe have been eagerly anticipating a multipurpose product to become available on the market here with this detector size and minimal housing dimensions. The housing of Toshiba's 30 x30 cm FPD is actually even smaller than dedicated 20 x 20 cm FPD cardio-interventional systems available from other vendors.

The Infinix VF-i/SP produces exceptional image quality, it is extremely versatile and it is suitable for a broad range of applications and thus offers many

Gelre Hospital's new building at Zutphen has been in use since late 2010

"The image quality of this machine is **exceptionally good."**

additional benefits for the entire medical imaging team. During my career, I have worked with all major equipment vendors and have found that Toshiba offers a consistently outstanding, interactive service. This was an important factor in our decision to purchase the system. We will be working with the system for many years, so we needed a vendor who can guarantee reliable service for the lifetime of the machine. In combination with the unique specification of the Infinix VF-i/SP with 30 x 30 cm FPD, it was a major plus in Toshiba's favour.

We already have a Toshiba Infinix CF-i/SP system at Gelre Hospital Apeldoorn that has been in use for a couple of years. The positive experience we have had with this system contributed to the decision to purchase the Infinix VF-i/SP in Zutphen.

Some of my colleagues were not very familiar with Toshiba's range of equipment, but when they were informed about the specifications and capabilities of the new system and its affordability, they were immediately convinced that this was the best choice for Zutphen's new Cath Lab.

VISIONS: *Was the installation of the new system difficult?*

Dr de Jong: Not at all. The installation of the new machine went very smoothly. It was scheduled to take place before the completion of the new building that means before the hospital became fully operational. Together with Toshiba, we designed a generous timeframe and the Toshiba installation team collaborated at every stage of the installation process: planning, actually installing the equipment and calibrating the new machine for use. I followed each stage with great interest and thought the whole project was beautifully executed.

Once the new system was operational, there was hardly any training necessary – which bears witness to the ease of use of this machine. It was simply a question of programming each specialist's preferred settings.

Now it is fully operational. The images from the Infinix VF-i/SP are easy to store and to retrieve and they integrate seamlessly with our IT system at Gelre Hospital.

VISIONS: *What do you particularly like about the Infinix VF-i/SP?*

Dr de Jong: The image quality of this machine is exceptionally good. It is even better than the images we generate with our Toshiba Infinix CF-i/SP system in Apeldoorn. Toshiba's Advanced Image Processing (AIP) technologies ensure that there is no lag and that precise, clear images can be obtained. This technology and the small size of the detector and its housing allow us to achieve the steepest of angulations. Images that display more detail enhance device guidance and deployment resulting in safer, faster procedures for the patient and clinical team.

The control room of Toshiba's Infinix VF-i/SP interventional angiography system at Gelre Hospital, Zutphen

The system is extremely easy to use and manoeuvre. With different procedures, cardiologists must frequently and rapidly switch the location of equipment. The manoeuvrability of the C-arm permits me to work from either side of the table. I am left-handed, which can raise additional problems in using some systems, but with the Infinix VF-i/SP, I experience no awkwardness in operation. Toshiba's tableside Hyperhandle console can easily be operated with one hand – be it left or right.

The speed of the operating arm is outstanding. This is particularly important when working with patients in a less stable condition. We must be able to take images quickly and effectively with minimal disruption to the patient.

VISIONS: *What do your colleagues think of the machine?*

Dr de Jong: Different medical disciplines here at Zutphen share the system – such as cardiologists, radiologists and the pain management group. Its use is truly multipurpose! The teams of each of these disciplines are very positive about the new system and the results it delivers.

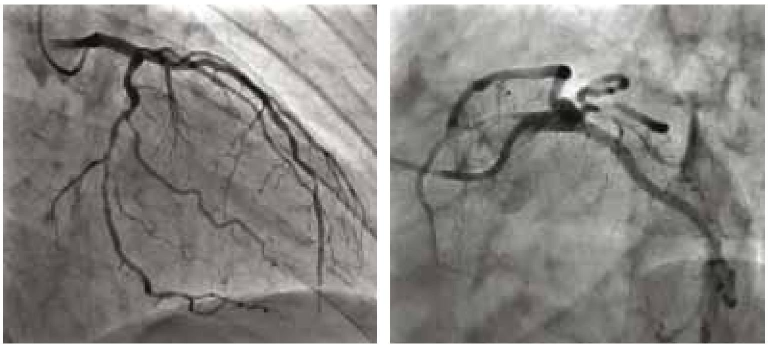
The Infinix VF-i/SP can store virtually any number of customized examination types for any number of operators. This is important at Zutphen with its wide range of multipurpose use. This unique Toshiba feature dramatically boosts our productivity.

The system simultaneously processes and transfers image data during acquisition – parallel processing. This means that during the course of one examination we can already prepare for the next scheduled patient. This is also a significant aid in improving patient throughput.

VISIONS: *How does the system broaden your options?*

Dr de Jong: Thanks to the versatility of the Infinix VF-i/SP, the cardiology team is able to perform additional procedures at this location. We have started using the system to perform Biventricular Pacemaker (BVP) implantation and we are considering performing diagnostic examinations for Intra-Aortic Balloon Pump (IABP) insertions with it in the near future. We are also currently working with the pulmonary team to explore procedures for examining pulmonary hypertension with the system. The latter is currently normally carried out in state-of-the art university hospitals, but with the new Infinix VF-i/SP it could become a possibility at Gelre Hospital Zutphen.

We are already using the system more intensively than we originally anticipated. It is estimated that we will perform 500 cardiology procedures with the new system this year alone. The system is helping us to implement many more life-saving procedures with far greater ease and accuracy than we could have imagined.



Digital Angiography and high quality fluoroscopy imaging with Toshiba's Infinix-i-series.

VISIONS: *Is there anything about the system that you think could be improved?*

Dr de Jong: To be totally honest - absolutely nothing! I am delighted with the results we are obtaining with the system, the enhanced efficiencies it brings for our team and the improved care that we can offer our patients.

With the added reassurance of an excellent ongoing service for the life of the machine, I am confident that any technical or application issues that we may encounter in the future will be addressed by Toshiba with great care and consideration.

VISIONS: *Thank you!*

Infinix-i Volume Navigation – 3D roadmapping made simple

Trackind every curve, every move, every image

Toshiba's easy-to-use, real-time Volume Navigation 3D roadmap links every Infinix-I system movement with the fusion 3D and fluoroscopic display. So regardless of changes in table position, Source-Image-Distance (SID), Field-of-View (FOV) or C-arm angulation, the 3D overlay remains constantly aligned with the fluoroscopic image within an industry-leading 1.5 mm degree of accuracy. Along the way, Volume Navigation gives physicians greater confidence in interpreting complex vascular structures so that they can perform complicated interventions such as cerebral aneurysms more quickly, reducing radiation and contrast dose for patients.

To further assist physicians in making difficult decisions, Volume Navigation also provides simultaneous 2D and 3D roadmap display modes and allows physicians to fine-tune images with easy-to-use manual controls for device enhancement and display modes for Volume Rendering (solid vessel) and Edge Enhance Rendering (hollow vessel).

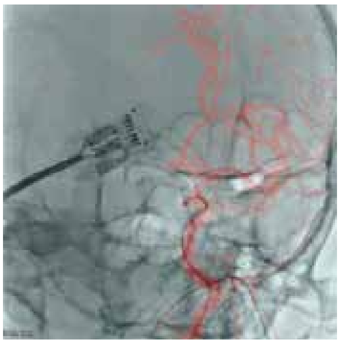


Fig. 1: First coil begins to enter the aneurysm from the micro-catheter

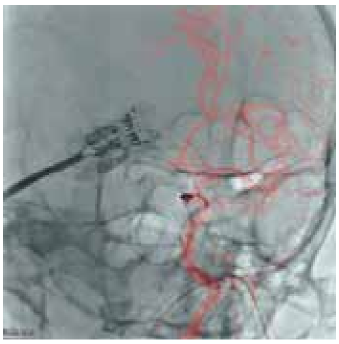


Fig. 2: First coil about half-way into the aneurysm. A section of platinum coil can be seen in the parent vessel

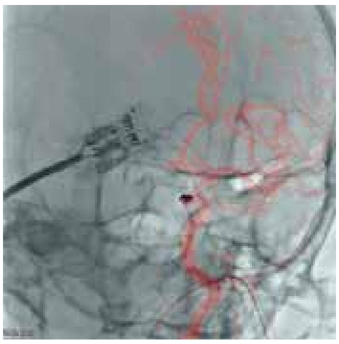


Fig. 3: First coil fully deployed into the aneurysm

Optimizing the dispay at every stage of intervention

Volume Navigation takes 3D roadmapping to the next level with two display modes and three manual adjustments that can be used to optimize the image at any stage of the procedure. These features give clinicians the tools they need to navigate complex anatomy with greater confidence and control.

- Simultaneous 2D roadmap and 3D roadmap displays on separate monitors facilitate optimum solid or hollow vessel visualization and manipulation of interventional devices.

- Unique wire enhancement algorithms enhance visualization of wires and other interventional devices, particularly those comprised of low-density materials such as nitinol.
- A hollow vessel display adjustment improves visualization of complex AVM shunt vessels, while a solid vessel adjustment optimizes visualization in smaller vessels.

Volume Navigation displays the deployment of coils during a neuro-intervention with exceptional clarity and precision.

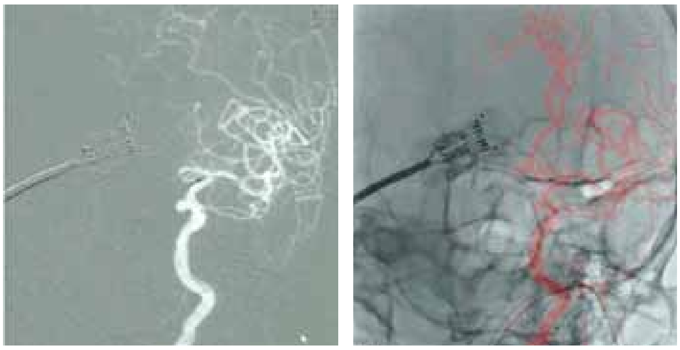


Fig. 4: Conventional subtracted 2D roadmap image (left). New 3D roadmap mage showing Volume Rendered display mode with moderate to high transparency setting (right).

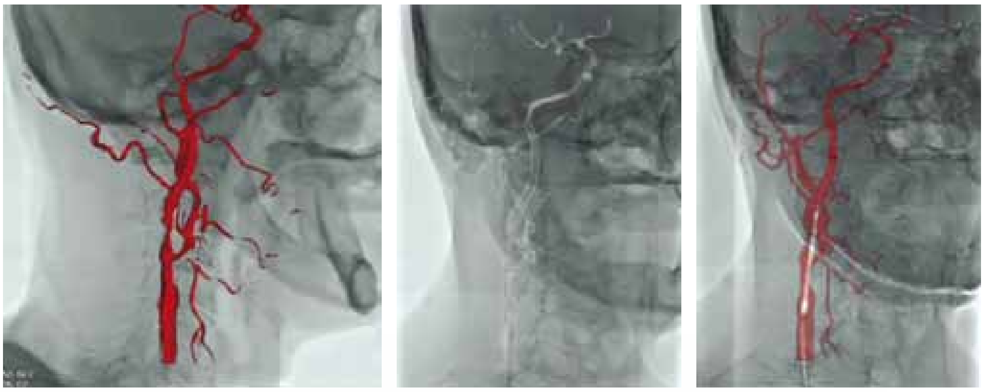


Fig. 5a: Volume Rendering display mode with vessel opacity high

Fig. 5b: Edge Enhance Rendering display mode (hollow vessels)

Fig. 5c: Device Enhance Processing applied to this 3D roadmap, markedly improving visualization of stent delivery

R/F at Creu Blanca Diagnosis Médica Clinic

A. S. Aznar

Antonio Salvador Aznar, MD

Winscope Plessart, Toshiba's remote controlled R/F system equipped with a digital image processor and 12" image intensifier, acquires high resolution images with outstanding diagnostic accuracy.

Dr Antonio Salvador Aznar is a radiologist at Creu Blanca Diagnosis Médica, Spain, where one of the first Winscope Plessart systems sold in Europe was installed in October 2008. He told VISIONS how the system is enabling Creu Blanca's specialists to perform a wider range of procedures with greater ease and increased efficiency.

The venue

Located in Barcelona, the capital of Catalonia, Creu Blanca Diagnosis Médica is one of the largest diagnostic centres in Europe. It is part of Creu Blanca group whose team of more than 150 medical professionals offer preventive screenings, consultations in all specialties, high-tech diagnostic tests and surgery with state-of-the-art technology.

The history of the Diagnosis Médica centre dates back to the 1980s. At a time when healthcare was provided mainly in large hospitals, a group of Creu Blanca doctors decided to create a centre that was completely specialized in diagnostics and could thus offer emergency diagnoses.

The technology

In October 2008 Toshiba Medical Systems installed a Winscope Plessart EX8 system in Creu Blanca Diagnosis Médica in Barcelona. After having evaluated digital remote controlled R/F systems from different vendors for digital imaging capabilities and clinical versatility, the Creu Blanca team chose the Toshiba system because of its overall price/performance ratio. Another point in favour of

Creu Blanca Diagnosis Médica Barcelona, Spain

The control room of the Winscope Plessart EX8 in Creu Blanca's Diagnosis Médica Clinic

Toshiba was the company's long and positive relationship with Creu Blanca.

The Winscope Plessart EX8 is not only used by five radiologists but also by many radiographers for general radiography tasks. The fluoroscopic procedures performed on the system are barium examinations of the digestive tract, intravenous urography, hysterosalpingography and arthrography.

Dr Antonio Salvador Aznar: "The image quality of fluoroscopic and radiographic images is very good and the Winscope Plessart offers enough flexibility to cover a wide range of clinical applications."

Reliability and service have high priority at Creu Blanca. Dr Aznar: "The Toshiba Winscope Plessart is a very reliable system. It is always ready to be used. The local service organization guarantees an uptime above 98%. It was very easy for radiologists and radiographers to adapt to the new system. Operations are quick and easy and application training was good."

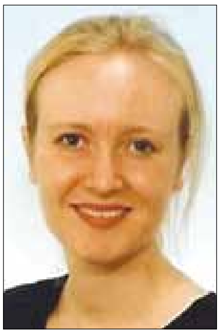
Future improvements to the Winscope Plessart, Aznar adds, "could be a 30 x 30 cm flat panel. The absence of cranial/caudal angulations is sometimes challenging, but the higher level model Toshiba Zexira was unfortunately beyond our budget".

Both at the diagnostic centre and at other Creu Blanca locations a wide range of Toshiba equipment is being used, such as the MRI systems Opart, Excelart and Excelart Vantage, the CT Aquilion 16, the Aplio MX ultrasound system and (interventional) x-ray systems.

Centros Médicos Creu Blanca's Diagnosis Médica Clinic is located in downtown Barcelona, Spain.

Diagnostic Accuracy of 320-Row CT and Challenging Case Scenarios

Fleur R. de Graaf, MD[1], Ernst E. van der Wall, MD PhD[1]



Fleur R. de Graaf, MD

Introduction

Computed tomography coronary angiography (CTA) is an emerging non-invasive tool for detecting significant coronary artery disease (CAD). With the introduction of 320-row CTA, with 320 simultaneous detector rows each 0.5 mm wide, the non-invasive evaluation of the entire heart in a single heartbeat and volume has become possible (Figure 1). While previous helical and step-and-shoot 64-row CT systems have a craniocaudal coverage of 3.2 cm per gantry rotation, 320-row CTA allows the volumetric coverage of up to 16 cm per scanner rotation (Figure 2). Volumetric scanning in combination with prospective ECG triggering enables image acquisition during a small portion of a single cardiac cycle, thus allowing for single heartbeat image acquisition. Due to fast image acquisition in a single volume, CT examination may be performed at low contrast and low radiation doses.

Diagnostic performance

Recent studies have determined excellent diagnostic performance of 320-row CTA in the evaluation of significant CAD (defined as ≥50% luminal narrowing). A study by Dewey et al, evaluating 30 patients with an intermediate pre-test likelihood of CAD, reported sensitivity, negativity, positive and negative predictive values of 100, 94, 92 and 100%, respectively, on a patient basis[2]. These findings were confirmed in a study assessing 64 patients using 320-row CTA[2]. Furthermore, excellent diagnostic accuracy of this technique in the evaluation of stenosis ≥70% luminal narrowing was reported[3]. Accordingly, due to the high negative predictive value, this technique is particularly useful to rule out significant CAD in patients with a low to intermediate pre-test likelihood. In case CTA results are normal, the patient may be safely discharged, at a low contrast and radiation dose. Figure 3 illustrates the use of 320-row CTA to exclude significant stenosis in a patient with suspected CAD. Furthermore, the sensitivity and negative predictive value of 100% show that this technique is not only suitable for the exclusion of CAD, but may also be useful for the diagnosis of significant stenosis as it is very unlikely to miss severe CAD. Figure 4 shows an example of 320-row CTA, identifying the presence of severe CAD.

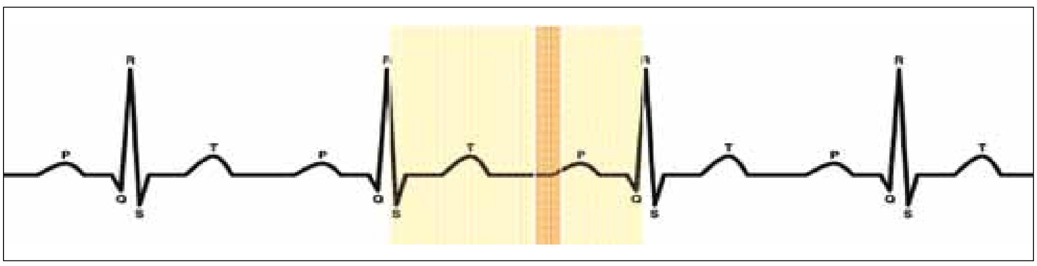
320-row CTA in clinical practice

With the introduction of wide-detector CTA, such as 320-row CTA, volumetric image acquisition has become possible, thus reducing time of image acquisition, time of breath-hold and contrast doses. Furthermore, using a volumetric imaging technique, the need for helical oversampling, observed in helical scanning approaches, is eliminated, thus reducing radiation exposure, while maintaining image quality and diagnostic performance. Moreover, patient-adapted scanning protocols allow for the evaluation of more challenging patients with good diagnostic accuracy.

Patient-adapted scanning approaches

320-row CTA allows for a patient-adapted scanning approach, enabling image acquisition of the heart with good image quality, even in more challenging patients, such as patients with elevated heart rates or unexpected arrhythmias.

Fig. 1: Volumetric 320-row CTA enables image acquisition in a single R-R interval. Using prospective ECG triggering, image acquisition is performed during a small, pre-defined portion of the R-R interval (red bar).



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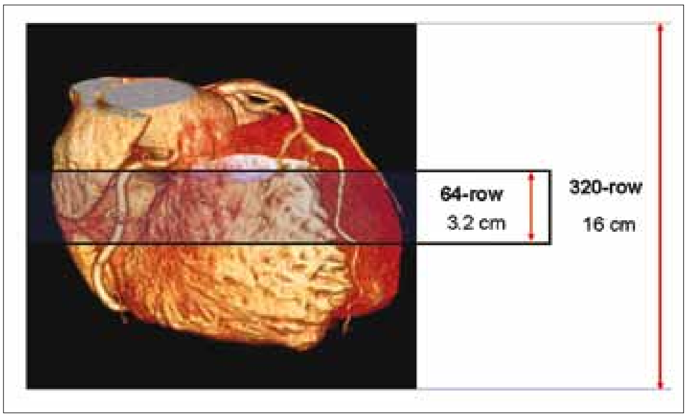


Fig. 2: 320-row CTA, with 320 simultaneous detector rows each 0.5 mm wide allows for a maximum of 16 cm volumetric coverage, enabling image acquisition of the heart in a single gantry rotation (Photo: courtesy of Toshiba Medical Systems).

Fig. 3: Single heartbeat 320-row CTA in a 39 year old female with atypical chest pain and with positive family history for CAD. CTA ruled out the presence of CAD and the patient was safely discharged. Panel A shows a three-dimensional volume rendered reconstruction of the heart. Panel B shows a normal right coronary artery. Panel C shows a normal left anterior descending coronary artery.

Elevated heart rate

Using 320-row CTA, single heartbeat imaging is performed in patients with low heart rates (heart rate below 65 bpm). Nevertheless, it is important to note that also in patients with elevated heart rate image acquisition may be performed at good image quality. At elevated heart rate above 65 bpm, image acquisition is performed during multiple cardiac cycles and multi-segmental image reconstruction is performed. As compared to half-segment reconstruction, used in scans acquired during a single cardiac cycle, multi-segment reconstruction improves temporal resolution, thereby improving image quality. As a result, good image quality may be attained in patients with elevated heart rates. Figure 5 shows an example of 320-row CTA of excellent image quality in a patient with persistent elevated heart rate despite beta-blocker administration.

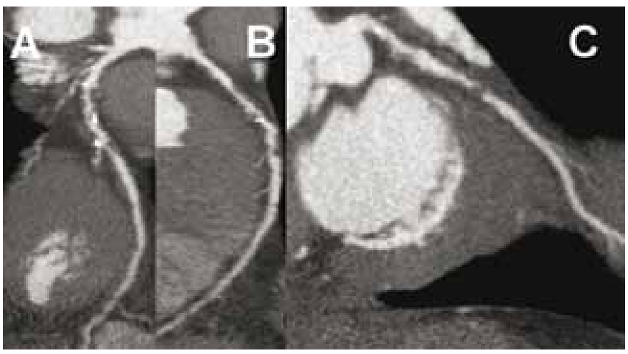
Arrhythmia rejection protocol

Importantly, even in patients with irregular heart rates, such as patients with cardiac arrhythmias, image acquisition of the coronary arteries is possible with this technique, using an arrhythmia rejection protocol[4]. When a scheduled R-R interval for image acquisition is abnormally short due to an R wave appearing prior to completion of imaging, such a protocol asks the system to reject this beat and to image the next R-R interval (Figure 6). Accordingly, even in patients with irregular heart rates good image quality of the coronaries is obtained at acceptable radiation doses. Recent data suggest that 320-row CTA indeed allows the evaluation of patients with atrial fibrillation, showing good CTA image quality in this patient population[5]. Figure 7 shows an example of a CT scan which was performed in a patient with an irregular heart rate demonstrating good image quality despite irregular heart rate during image acquisition.

Patients with a history of revascularization

Recently, the diagnostic performance of 320-row CTA in the assessment of coronary in-stent restenosis was assessed. In a group of 53 patients, with a total of 89 stents, sensitivity, specificity, positive and negative predictive values of 100, 81, 58 and 100%, respectively were shown[6]. Although the positive predictive value remained relatively low, the high negative predictive value showed that 320-row CTA has a high capacity for the exclusion of significant in-stent restenosis. Importantly, this study also

Fig.4: 320-row CTA of a 64 year old male with no previous cardiac history, presenting to the emergency department with unstable chest pain. ECG showed no abnormalities and troponin levels were normal. Curved multiplanar reformations revealing significant stenosis in the left anterior descending coronary artery (panels A and B) and left circumflex coronary artery (panel C).



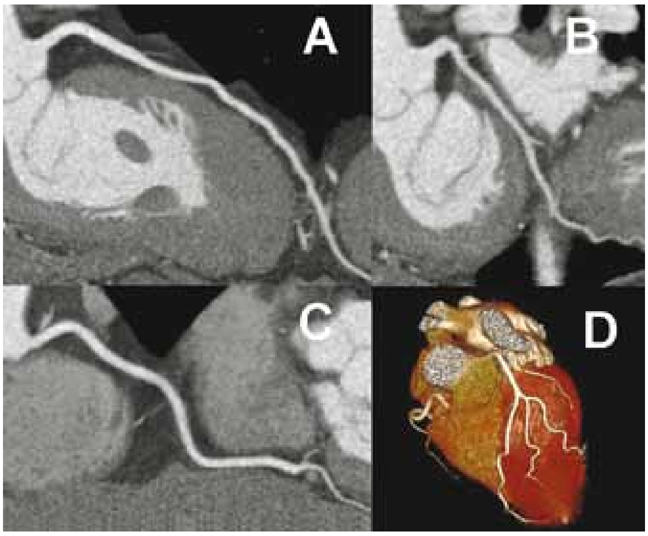


Fig.5: 320-row CTA of excellent image quality in a patient with an elevated heart rate, showing normal coronary arteries. Despite beta-blockers, heart rate remained 75 bpm during breath-hold. Panel A, B and C show the curved multiplanar reformations of a normal left coronary artery, left circumflex coronary artery and right coronary artery, respectively. Panel D shows a three-dimensional volume rendered reconstruction of the heart, with normal coronary arteries.

showed that, in contrast to most studies performed using 64-row CTA, no significant effect of heart rate on CTA image quality was observed. This is most likely due to the fact that in patients with an elevated heart rate (a heart rate above 65 bpm) CTA image acquisition is performed during multiple cardiac cycles. Subsequently, multi-segment reconstructions may be performed, still yielding diagnostic image CTA image quality even at increased heart rates. However, it is important to note that the diagnostic accuracy in small stents (<3 mm in diameter) and stents with thick struts (>140 µm) was decreased. These data imply that this modality may be useful for the evaluation of in-stent restenosis in carefully selected patients.

Also in the evaluation of patients with a history of coronary artery bypass grafting, CTA may allow evaluation of graft disease, as well as native coronary arteries and distal runoff vessels with good diagnostic accuracy[7]. Although studies addressing the diagnostic accuracy of 320-row CTA in the evaluation of coronary artery bypass grafts are currently not available, previous studies using 64-row CTA have reported diagnostic accuracies ranging between 90 and 95%[8]. Figure 8 shows an example of CTA in a patient with a history of coronary artery bypass grafting. Volumetric 320-row CTA in patients with previous coronary artery bypass grafting gives an immediate overview of anatomy and patency of bypass grafts and native coronary arteries, as well as distal runoff vessels.

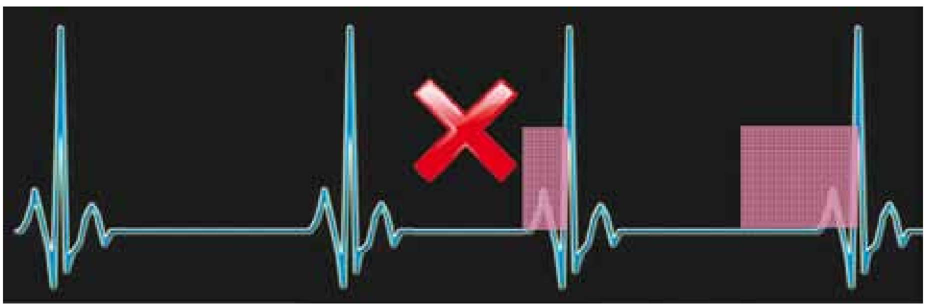
Simultaneous imaging of anatomy and perfusion

Volumetric CTA allows simultaneous imaging of anatomy and perfusion in a single examination. Myocardial perfusion imaging of the entire heart may be performed, resulting in full cardiac coverage with homogenous attenuation of the myocardium. Using this approach, the combined anatomical and perfusion imaging may be performed in a single investigation, allowing the detection of CAD causing perfusion abnormalities[9].

Limitations

Although 320-row CTA allows for fast image acquisition at low contrast and low radiation doses in patients with previous revascularization, CT is also associated with several limitations. Firstly, CT is inherently associated with patient radiation exposure. However, novel imaging techniques, such as prospective ECG triggering and volumetric imaging, have reduced radiation exposure. Second, in patients with surgical clips, extensive coronary calcifications or small stents or thick stent struts, the positive predictive value is decreased. Therefore, careful patient selection is important. Although it is important to note that this technique is most suitable for the exclusion of CAD in patients with a low to intermediate pre-test likelihood, in selected cases CTA may aid the diagnosis of patients with known CAD, such as patients with prior CABG in

Fig. 6: Arrhythmia rejection protocol allows CTA image acquisition in patients with irregular heart rate (Photo: courtesy of Toshiba Medical Systems)



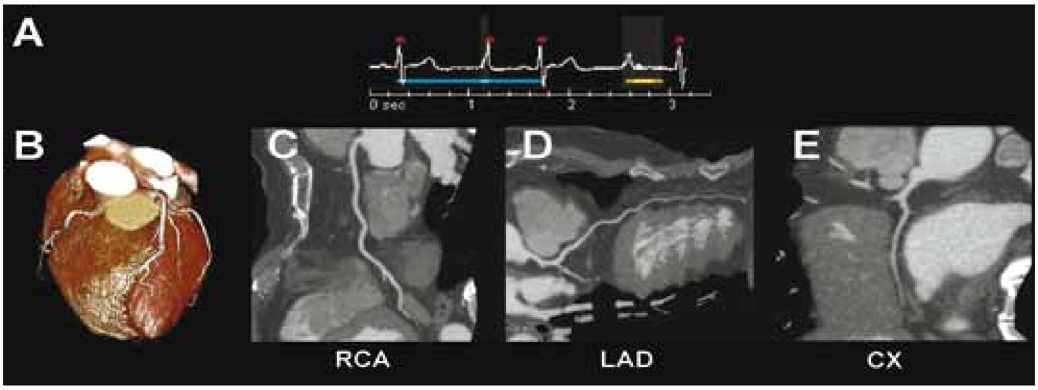


Fig. 7: Arrhythmia rejection protocol resulting in good image quality in a patient with irregular heart rate during image acquisition. Panel A shows the ECG during image acquisition of a patient referred for 320-row CTA. The scheduled R-R interval for image acquisition is abnormally short, as the R wave appears prior to completion of imaging. The system rejects the abnormally short beat (blue) and images a next R-R interval (yellow). Panel B shows a three-dimensional volume rendered reconstruction of the heart. Panels B, C and E illustrate curved multiplanar reformations of normal coronary arteries. Definitions: CX: left circumflex coronary artery; LAD: left anterior descending coronary artery; RCA: right coronary artery.

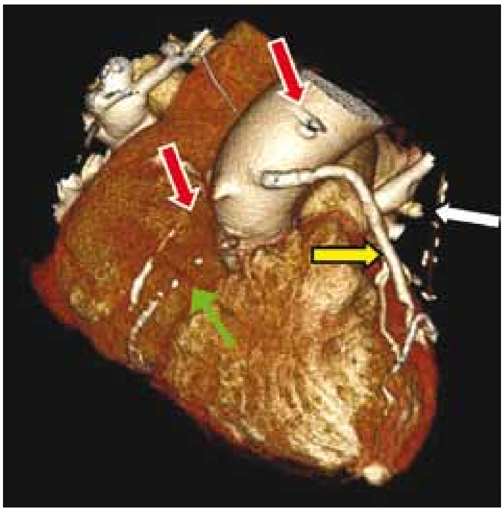


Fig. 8: Single volume 320-row CTA providing an immediate overview of anatomy and patency of coronary artery bypass grafts and native vessels in a patient with previous coronary artery bypass grafting. Two occluded venous bypass grafts to the right coronary artery (red arrows), an occluded arterial (LIMA) graft to the left anterior descending coronary artery (white arrow), an occluded right coronary artery (green arrow) and a patent sequential venous graft to the left anterior descending coronary artery and first diagonal branch are observed. Definitions: LIMA: left internal mammary artery

whom graft anatomy and patency are lacking. Lastly, in all patients referred for CTA, heart rate reduction remains important to reduce radiation exposure and optimize image quality.

Conclusion

Novel 320-row CTA allows for a volumetric scanning approach, offering excellent diagnostic performance in the evaluation of CAD. As image acquisition is performed in a single heartbeat or volume, this technique enables fast image acquisition with short breath-hold at low contrast and low radiation doses. Moreover, due to the volumetric imaging approach, step-artefacts are eliminated. Furthermore, this technique allows for the simultaneous imaging of anatomy and perfusion.

Due to patient-adapted scan protocols, this modality enables evaluation of CAD in a variety of patients. High diagnostic accuracy has been reported for single heartbeat imaging in patients with suspected CAD. However, also in patients with elevated heart rate, multi-segment reconstructions may still yield good image quality. Even in patients with irregular heart rates due to cardiac arrhythmias such as atrial fibrillation, good image quality may be achieved using an arrhythmia rejection protocol. Furthermore, good diagnostic accuracy of 320-row CTA has been determined for the evaluation of patients with a history of revascularization such as the evaluation of in-stent restenosis. Last, the presence of graft anatomy and graft disease may be determined using volumetric CTA.

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Clinical Cases of Myocardial Perfusion Using 320-Row CT: Comparison with CMR

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The major cause of cardiovascular morbidity and mortality is coronary atherosclerosis which causes myocardial ischemia. Effective and accurate methods for identification of clinically significant ischemia are crucial.

Myocardial perfusion has classically been assessed electrocardiographically and with radionuclide perfusion imaging. More recently, cardiac magnetic resonance (CMR) imaging has played and increasing role in evaluating perfusion as it compares favourably with radionuclide[1].

Technological advances in multidetector computed tomography (MDCT) have allowed the assessment of coronary anatomy in terms of both the degree of luminal stenosis and the characterization of coronary wall plaques. In addition, there is growing evidence with regard to the potential value of the technique for the assessment of myocardial perfusion itself. The technique is based on changes in myocardial attenuation induced by the arrival of the contrast bolus and measured by means of values of Hounsfield units (HU).

This will allow for a comprehensive CT study of the patient with ischaemic heart disease. The potential role of cardiac CT for this purpose is being actively explored at present[2-6] as this would represent a substantial step towards the development of an optimal non-invasive test in the evaluation of patients with CAD.

Since there is currently no standard protocol, neither for image acquisition nor for the analysis of the resulting images, the following specific proposal for a 320-row CT system was developed:

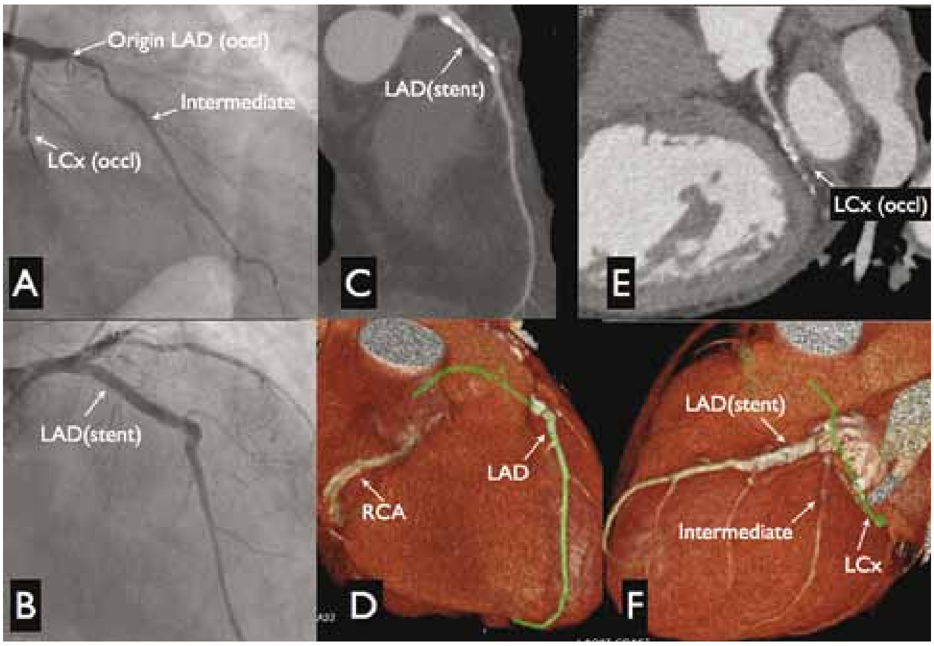
- **Scanner used:** Toshiba 320-row detector Aquilion ONE
- **Volumetric** acquisition, prospective triggering
- **Tube voltage:** 100 kV
- **Tube current time product:** 140-175 mAs
- **Field of view (FOV):** 21 cm. Scan matrix: 512 x 512.
- **Scan length:** 60-70 mm, adjusting the limits of acquisition in the z-axis to include only the left ventricle
- **Reconstruction kernel:** FC4.
  Filter: QDS+
- **DLP** (entire protocol: coronary CTA -1 beat-; myocardial perfusion stress + rest):
  420 mGy×cm which corresponds to 5.88 mSv
  (k-factor = 0.014 mSv×(mGy×cm)-1)
- **Rotation time:** 350 ms
- **Slice collimation:** 320 × 0.5 mm
- **Reconstruction increment:** 0.25 mm
- **Drug stress:** adenosine infusion (Adenoscan 140 mcg/kg/ min) over 4 minutes
- **IV contrast:** Xenetics 350 mg/ml.
  Bolus of 0.8 ml/kg followed by 40 ml of saline (given at stress and rest perfusion acquisitions)
- **Injection rate:** 5-6 ml/s
- **Scan acquisition:** 5-7 s after the theoretical coronary acquisition time
- **Sequence of coronary and stress/ rest perfusion acquisitions:**

The rest acquisition includes the coronary CTA and, within 5-7 seconds and still with the same bolus of contrast, the myocardial perfusion acquisition. This protocol is advantageous as perfusion images are acquired at the peak of the myocardial contrast enhancement and the left ventricular cavity has a lower amount of contrast, thus avoiding beam hardening artefacts.

Usually the stress acquisition is performed first, followed by a 10-15 min myocardial washing phase and the rest study. If the patient, however, has a known previous myocardial infarction, the protocol is started by the rest perfusion acquisition. This is done to avoid a potentially false positive inducible defect due to the presence of late contrast enhancement in the scar region which would reduce the extension of the visible defect at the rest images when performed later.

– Analysis (Vitrea Workstation):
Module of perfusion analysis modified: window W/L: 130/130; analysis of transmural perfusion ratio2,3 (TPR; subendocardial attenuation density/subepicardial attenuation density) on average images (10-15 mm thickness) in cardiac axes: short and long axis views (two and four chambers).

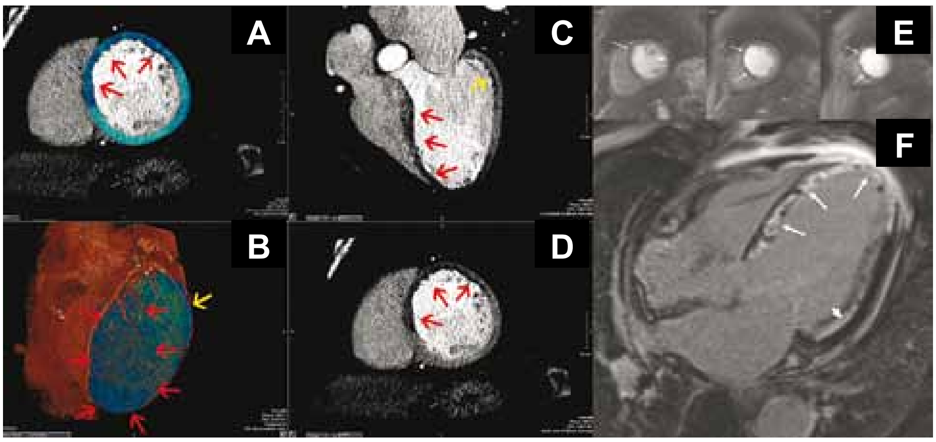
Case 1



68-year-old male, active smoker with no history of coronary artery disease (CAD). Current clinical presentation: acute anterior myocardial infarction.
Invasive coronary angiography (ICA): Occluded proximal LAD and chronic total occlusion of LCx artery.
A primary PTCA and stenting of the LAD was performed.
CMR: Antero-septal large myocardial necrosis mainly transmural and subendocardial necrosis at the basal third of the lateral wall, with corresponding rest perfusion defect at the first pass contrast study.
Cardiac MDCT study: Patent stent at the proximal LAD artery and occlusion of the LCx artery at the coronary CTA study. A large antero-septal rest perfusion defect is seen as well as a non-transmural defect at the basal lateral wall, both matching the defects described in the CMR exam.
Representative images are displayed in Figures 1 and 2

Fig. 1 A-B: ICA showing an occluded ostial LAD and chronic total occlusion of LCx artery (A); a patent LAD is seen after stenting (B). C-F: Coronary CTA study shows a patent stent at the proximal LAD artery (C-D) and occlusion of the LCx artery (E,F).

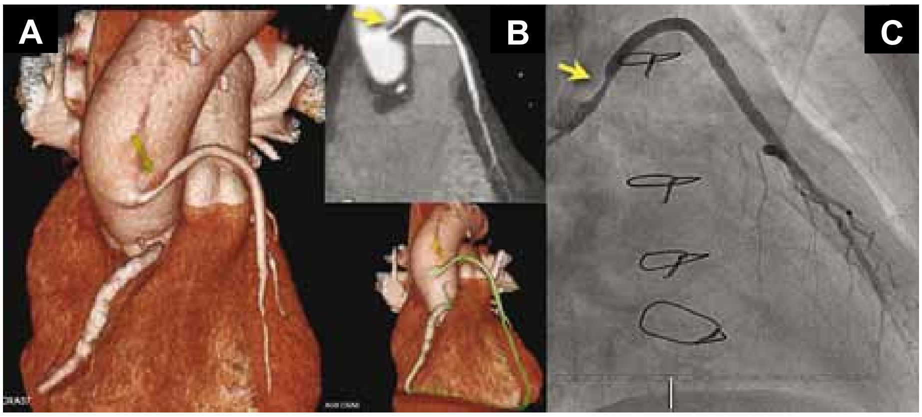
Fig. 2 A-D: MDCT study showing colour parametric images (A and B) representing the values of transmural perfusion ratio (TPR) superimposed on the grey scale images (C and D): a large transmural anterior defect (red arrows) and a smaller subendocardial defect at the basal lateral wall (yellow arrow) are seen. E-F: CMR exam showing the rest first pass contrast study (E) confirming the presence of the anterior (arrows) and lateral (arrowhead) defects. A delayed contrast enhancement study (F) proves the existence of a nearly transmural necrosis at the septum and apical regions (arrows) and at the basal lateral wall (arrowhead). Note the presence of signs of microvascular obstruction areas represented as small foci of hypointense dark areas within the necrotic hyperintense scar.



Conclusion

Adenosine stress CT can identify rest and stress-induced myocardial perfusion defects for which it seems to be comparable to CMR with the advantage of providing information on coronary stenosis. CT perfusion may add incremental value to cardiac CT angiography in the detection of significant CAD.

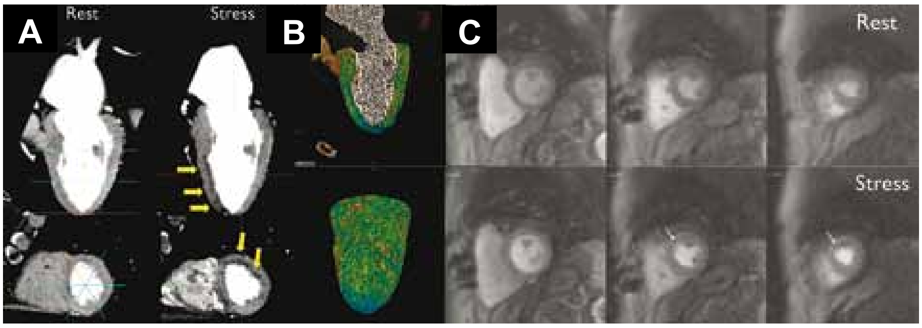
Case 2



66-year-old male, past smoker with hypertension, type II diabetes and hypercholesterolemia. Cardiac history: Unstable angina in 2001 treated by saphenous vein bypass graft to the LAD. Current clinical presentation: Progressive angina. Cardiac MDCT study: Fibrocalcified lesion at the proximal portion of the saphenous vein graft with significant stenosis.
An adenosine stress and rest myocardial perfusion study was performed (see protocol above) showing an inducible subendocardial defect at the anterior left ventricular wall with no defect at rest. CMR: Confirms the finding of an inducible anterior perfusion defect in the absence of myocardial necrosis.
Invasive Coronary Angiography (ICA): confirms the finding of a significant lesion at the proximal segment of the graft, which was subsequently treated by PTCA and stenting provided the inducible perfusion defect shown at MDCT and CMR. Representative images are displayed in Figures 3 and 4.

Fig. 3 A-B: MDCT study showing a fibrocalcified lesion with significant stenosis at the proximal portion of the saphenous vein graft. C: ICA confirms the presence of a significant lesion at the proximal segment of the graft.

Fig. 4 A-B: MDCT study showing grey scale (A) with images at rest (left) and at peak adenosine stress (right). An inducible subendocardial perfusion defect (arrows) is seen to appear during stress, with the corresponding colour parametric images at the peak stress in B. C: CMR perfusion study at rest (top) and during peak adenosine stress (bottom) confirms the inducible defect at the medial and apical anteroseptal region (arrows).



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Radiation Dose Reduction Techniques in 320-Row Detector CTCA

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Introduction

Computed tomography coronary angiography (CTCA) is now an established technique for the investigation of coronary heart disease. Advances in computed tomography technology have lead to improvements in both image quality and radiation dose. Although the average radiation dose for CTCA is 12 mSv[1] it is now possible to image the heart at radiation doses below one milliSievert[2].Radiation exposure is a major healthcare concern, particularly in younger patients who are susceptible to an increased lifetime risk of cancer. A variety of techniques have been applied to reduce the radiation dose from CTCA such as patient tailored protocols, electrocardiogram gating, dose modulation and heart rate reduction[3]. Here we will focus on radiation dose reduction techniques that can be applied to volumetric computed tomography scanning with a 320-row detector scanner.

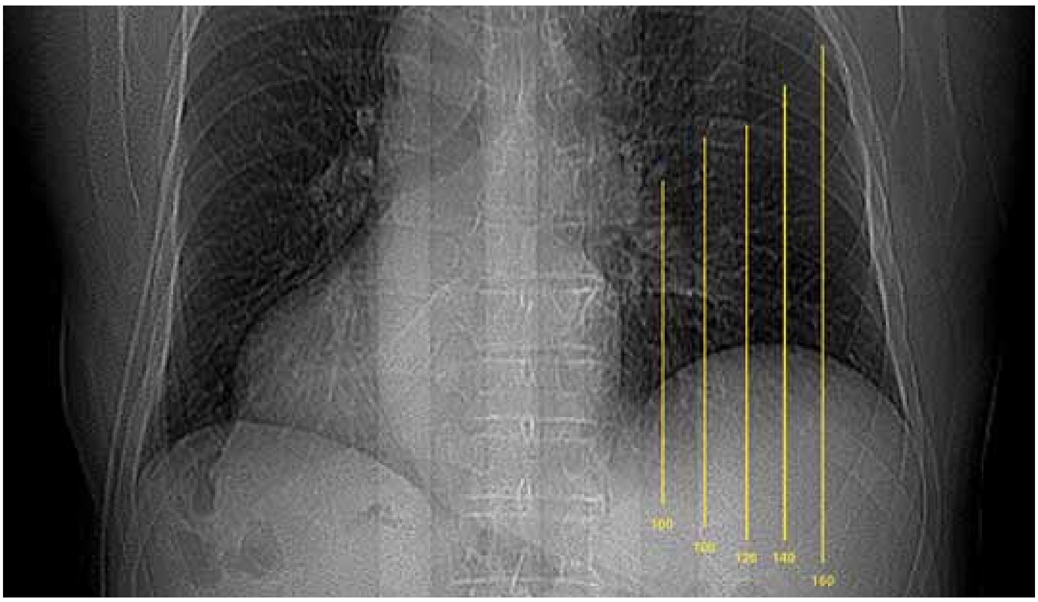
Patient selection

For each individual patient the risk and benefit of exposure to diagnostic radiation must be evaluated. Published appropriateness criteria can aid patient selection[4]. The aim during imaging should be to maintain radiation exposure "as low as reasonably achievable" (the ALARA principle) while maintaining diagnostic accuracy.

Heart rate reduction

Higher heart rates or heart rate variability during CTCA increase the likelihood of motion artifacts in the coronary arteries that can decrease diagnostic accuracy. The mean velocity of the right coronary artery is higher than the left anterior descending or left circumflex arteries and thus it is particularly prone to motion artifact[5]. Both absolute heart rate and heart rate variability have an important impact on image quality. A heart rate less than 60 beats per minute is thus desired to obtain the best image quality at the lowest radiation dose. This can be achieved by administering rate-limiting medication such as intravenous or oral metoprolol, verapamil or ivabradine.

Fig. 1: A scout image showing the effect of reducing detector range on scan coverage for 160, 140, 120, 128 and 100 mm volumes



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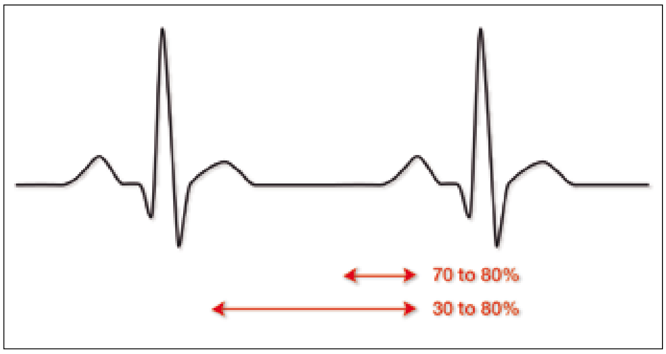

Fig. 2: An electrocardiogram trace showing two potential phase windows for CTCA

Scout images

Scout images (also known as scanogram, topogram, localizer, survey or pilot scans) are acquired to allow the planning of subsequent components of the CTCA. These are low dose scans, but they nevertheless contribute to the total radiation exposure. Scout images can be obtained in the postero-anterior orientation in order to reduce breast radiation dose[6]. They must be of adequate image quality to enable planning but detailed anatomical information is not required. Optimizing acquisition parameters for scout images such as tube current and voltage can decrease the total radiation dose for cardiac CT by up to 3.5%[7].

Bolus tracking and timing bolus

The CTCA can be commenced at the optimum time using either bolus tracking or a timing bolus. These components of the scan can account for 7% of the total radiation dose[8]. Bolus tracking takes recurrent, thin low dose images to track the inflow of contrast into the left ventricle. However, when iodinated contrast is injected into the anticubital fossa there is a delay before it reaches the heart. In addition, as with the scout images, tube current and voltage can be optimized based on body habitus. Thus with delayed, low dose, intermittent bolus tracking the radiation dose of CTCA can be reduced[9].

Detector range

Radiation dose increases proportionally with detector range. The maximum collimation of the Aquilion ONE in the z-direction is 160 mm but ranges of 140, 128, 120, 100 and 80 mm can also be used for cardiac imaging (see Figure 1). In our experience most patients can be scanned with a detector width of 120 or 128 mm. Reducing the scan range from 160 to 120 mm can decrease radiation dose by 25%. Thus tailoring the length of the scan volume to the individual patient can reduce radiation dose. Although traditionally the carina has been selected as the upper landmark for CTCA, a position two centimeters below this is usually adequate to cover the coronary arteries. If a coronary artery calcium score is performed prior to the CTCA, this can be used to

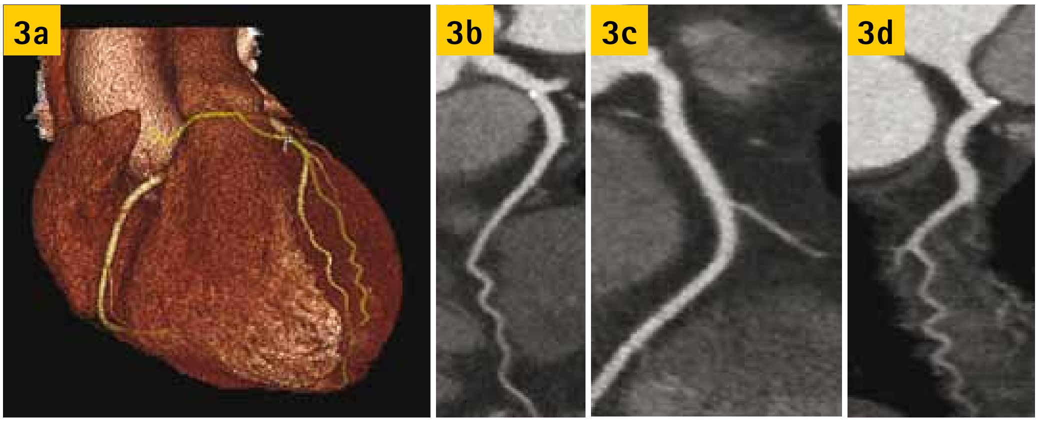

Fig. 3: Computed tomography coronary angiography images from a 60-year-old female patient with chest pain. Patient and scan parameters were: BMI 24, heart rate 63 after 25 mg intravenous metoprolol, 50 ml Iomeron 400 contrast, tube voltage 100 kV, tube current 440 mA, scan range 140 mm, half-scan reconstruction and phase window 70-80%. I mages were reconstructed using AIDR. The total dose length product was 137.7 (1.9 mSv using a k-factor of 0.014). A: Three-dimensional reconstruction of the heart. Curved planar reconstructions of B: left anterior descending artery, C: right coronary artery and D: left circumflex artery. E: Cross sectional image of the calcified plaque in the left anterior descending artery.

further reduce the radiation dose by setting the scan length to include 1cm above and below the heart[10].

Tube voltage and current

It is important to tailor the tube voltage and current to the individual patient in order to achieve optimal image quality at the lowest possible radiation dose. Increased body mass index is associated with a decreased image quality[11]. However, body mass index is a surrogate marker of body habitus and a variety of other methods have been proposed to optimize scan parameters for individual patients. These include using chest circumference or chest diameter on scout images[11].

Phase window

The CTCA image acquisition is electrocardiogram gated and can be performed in a single heart beat. A narrow window of acquisition reduces the radiation dose and can obtain diagnostic image quality in 90% of patients[12]. In patients with a heart rate less than 65 beats per minute, we use a phase window of 70 to 80% covering end-diastole (Figure 2). As the heart rate increases, the chance of motion artifact increases and the phase window can be increased to cover end-systole. A phase window of 30 to 80% covers the periods of iso-volumetric contraction and relaxation when the coronary artery motion is slowest[3]. An alternative is to increase the number of segments that are exposed to two or three depending on the heart rate to cover end-diastole. However, this increase in temporal resolution does come at the cost of increased radiation dose.

Adaptive iterative dose reduction

Iterative reconstruction was the technique originally used by Hounsfield in early computed tomography scanners. Adaptive iterative dose reduction (AIDR) is an iterative algorithm where noise is reduced from the original data, the results are analyzed and the process is repeated until the target level of noise reduction is achieved. The resulting image is weighted and combined with the filtered back projection reconstruction to create the final image. Advances in image reconstruction technology have the potential to improve image quality, and consequently reduce radiation dose. Typically, the degree of dose reduction with AIDR ranges from 67 – 73%[13].

Conclusion

It is important to optimize scanning protocols in order to reduce radiation dose, while maintaining image quality. Radiation dose in 320-multidetector computed tomography coronary angiography can be minimized by heart rate reduction, minimizing the detector range, optimizing scout images and bolus tracking, reducing the phase window, tailoring the tube current and voltage to the individual patient and applying new iterative reconstruction techniques. An example of the images that can be obtained using these techniques can be seen in Figure 3. Future advances in technology will enable further reduction in CTCA radiation dose with improved image quality.

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Coronary CT angiography with Aquilion ONE – clinical cases

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Case 1

Aneurism at the vein graft to the right coronary artery

Fig. 1: Overview over the heart with the RCA and the vein graft in the center of the image

Patient history: A 57-year-old male was admitted to the hospital with severe chest pain and suspicion of acute myocardial infarction. The ECG showed signs of acute ischemia.

15 years prior to this event the patient had been diagnosed with severe ischemic heart disease and received a coronary artery bypass with a left internal thoracic artery (LITA) to the left ascending artery (LAD) and a vein graft to the right coronary artery (RCA). 5 years after this procedure a stent was placed in the circumflex artery (CX).

Fig. 2: Sagittal display of the heart with the calcified aneurism and the relation to the surrounding structures

Fig. 3: Coronal display of the heart with aneurism and its relation to the right atrium

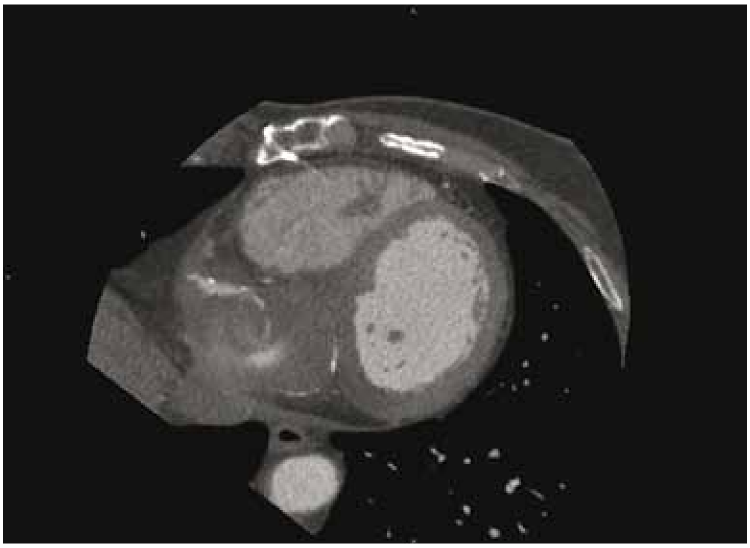

Fig. 4: Axial display of the heart with the aneurism and a part of the partly occluded vein graft

Through the last three years the patient experienced increased dyspnea and several cases of orthostatic dizziness and syncope.

Diagnosis: A coronary angiography showed an occluded LITA and a suspicion of a large aneurism at the vein graft to the RCA. Because of the possibility of thrombosis of the aneurism and its location close to the right atrium, percutaneous coronary intervention (PCI) was not an option. The patient was referred to the radiology department for a coronary CT angiography to determine the exact anatomy of the aneurism and the involvement of the surrounding structures.

Coronary CT angiography using the Aquilion ONE prospective volume scan showed a subtotal occluded vein graft with an aneurism measuring 5-7 cm in diameter with a possible partly compression of the inferior vena cava and the right atrium. The LITA graft and the RCA were totally occluded and the LAD was without significant stenosis.

The results of the coronary CT angiography were consistent with the clinical symptoms. The subtotal occlusion of the vein graft to the RCA led to chest pain. The compression of the inferior vena cava and the right atrium could explain the increased dyspnea and the syncope and dizziness.

Based on the coronary CT angiography and the clinical symptoms the patient was discharged and referred to a control CT angiography 6 months later for possible surgical removal of the aneurism.

Comments:a By using the Aquilion ONE to perform the coronary CT angiography we were able to identify the aneurism and especially determine the relation to the surrounding structures and thereby provide the exact diagnosis and treatment for the patient. Despite the fact that the patient did not respond to beta blockers the images were of excellent quality.

Table 1: Clinical protocol

Scanner	**Aquilion ONE**	**Scanner**	**Aquilion ONE**
Scan mode	Prospective	**Effective dose**	12.5 mSv
Scan area	Heart	**Slice width**	0.5 mm
Scan length	140 mm	**Slice collimation**	160 x 0.5 mm
Scan direction	Cranio-caudal	**Pitch**	N/A
Scan time	2.2 s	**Reconstruction increment**	0.25 mm
Heart rate	69 bpm	**Reconstruction kernel**	FC3
Tube voltage	120 kV	**BMI**	26.9
Tube current	450 mA	**Beta blockers**	no
Modulation	none	**Contrast**	Visipaque 320
Rotations	2	**Volume**	90 ml
Rotation time	0.35 s	**Flow**	6 ml/s
CTDI^{vol}	63.90	**Auto trigger at 180 HU**	
DLPe	894	**in the descending Aorta**	

Case 2

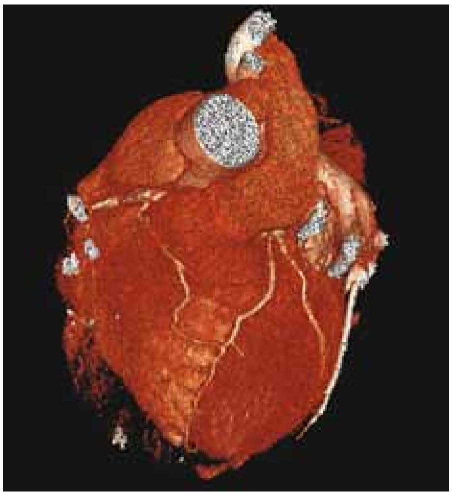

Fig. 1: Overview of the heart with the right coronary artery in the center of the image

Coronary anomaly

Patient history: A 62-year-old male with acute chest pain was admitted to the cardiology department for observation. The ECG and cardiac enzymes were normal and an acute myocardial infarction was ruled out. An exercise test was positive and the patient was referred for coronary angiography.

Diagnosis: The coronary angiography could only identify one coronary artery from the aorta. A coronary CT angiography performed on the Aquilion ONE with a prospective scan volume confirmed that the patient only had a right coronary artery (RCA) from the right sinus continuing into the circumflex artery (CX) and into a small left ascending artery (LAD). There are no significant stenoses in the artery but a borderline mixed soft and calcified plaque in the second part of RCA. In addition a myocardial scintigraphy was performed showing reversible ischemia

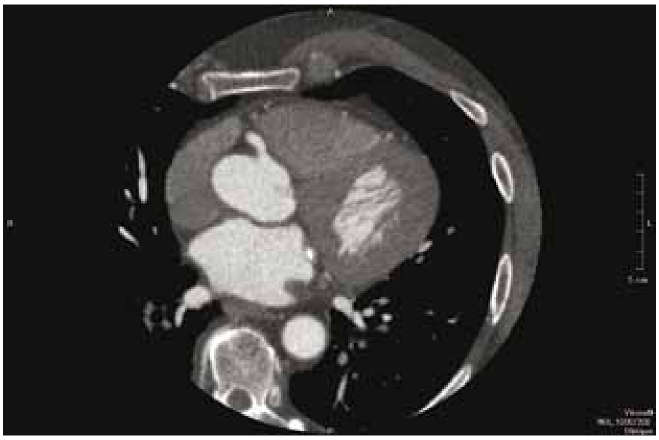

Fig. 2: The proximal part of the right coronary artery

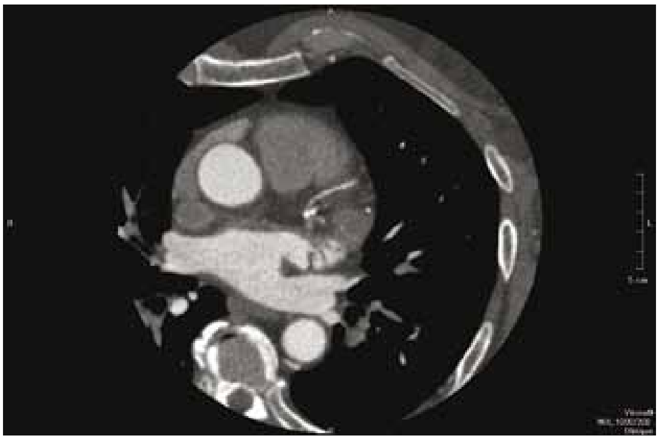

Fig. 3: : The distal part of the right coronary artery where it continues into a small left ascending artery

in the left ventricle. Presenting with only one coronary artery the patient is at increased risk of an acute myocardial infarction in the future.

Based on the coronary CT angiography, the myocardial scintigraphy and the clinical symptoms, the patient was offered a coronary artery bypass graft (CABG) with a left internal thoracic artery (LITA) to the LAD.

Comments: In this examination using the Aquilion ONE prospective scan in a patient with a heart rate of 49 beats per minute after beta blockage of 150 mg metoprolol, we were able to obtain good images at a dose of 3.2 mSv. Based on these images we were able to provide the optimal treatment for the patient in order to diminish the risk of a potential acute myocardial infarction in the future.

Fig. 4: Curved planar reformatted display of the right coronary artery visualizing the borderline mixed plaque proximal in the right coronary artery

Table 1: Clinical protocol

Scanner	Aquilion ONE	Scanner	Aquilion ONE
Scan mode	Prospective	**Effective dose**	3.2 mSv
Scan area	Heart	**Slice width**	0.5 mm
Scan length	128 mm	**Slice collimation**	160 x 0.5 mm
Scan direction	Cranio-caudal	**Pitch**	N/A
Scan time	1.2 s	**Reconstruction increment**	0.25 mm
Heart rate	49 bpm	**Reconstruction kernel**	FC3
Tube voltage	120 kV	**BMI**	31.8
Tube current	5500 mA	**Beta blockers**	150 mg
Modulation	none	**Contrast**	Visipaque 320
Rotations	1	**Volume**	90 ml
Rotation time	0.35 s	**Flow**	6 ml/s
$CTDI_{vol}$	18	**Auto trigger at 180 HU**	
DLPe	231	**in the descending Aorta**	

The Clinical Benefits of 320-Row CT in the Emergency Department

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Introduction

Diagnosis and investigation of patients who present to the emergency department with chest pain continues to be a difficult problem despite technological advances and improved availability of new investigative techniques. This is unfortunate because clinical history and physical examination, although suggestive, are not definitive for myocardial ischemia in most patients. In the USA alone there are more than six million patients who present to the emergency services with chest pain related emergencies. The cost of chest pain triage and management has been estimated to be as high as $8 billion annually, with most of those patients ultimately not having acute coronary syndrome (ACS)[1].

In 2006, coronary heart disease (CHD) cost the healthcare system in the UK around £14.4 billion. There are 94,000 deaths from CHD in the UK each year[2]. It is the most common cause of death in the UK. 20-40% of all medical admissions are for acute chest pain[3,4]. In our hospital there are approx. 8,000 emergency depart-

Fig. 1

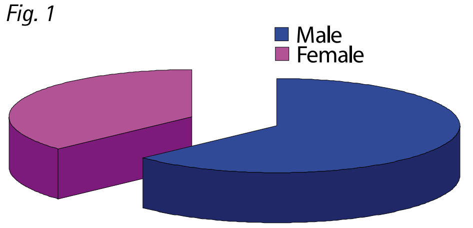


Fig. 2

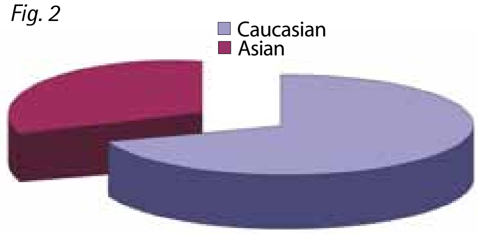
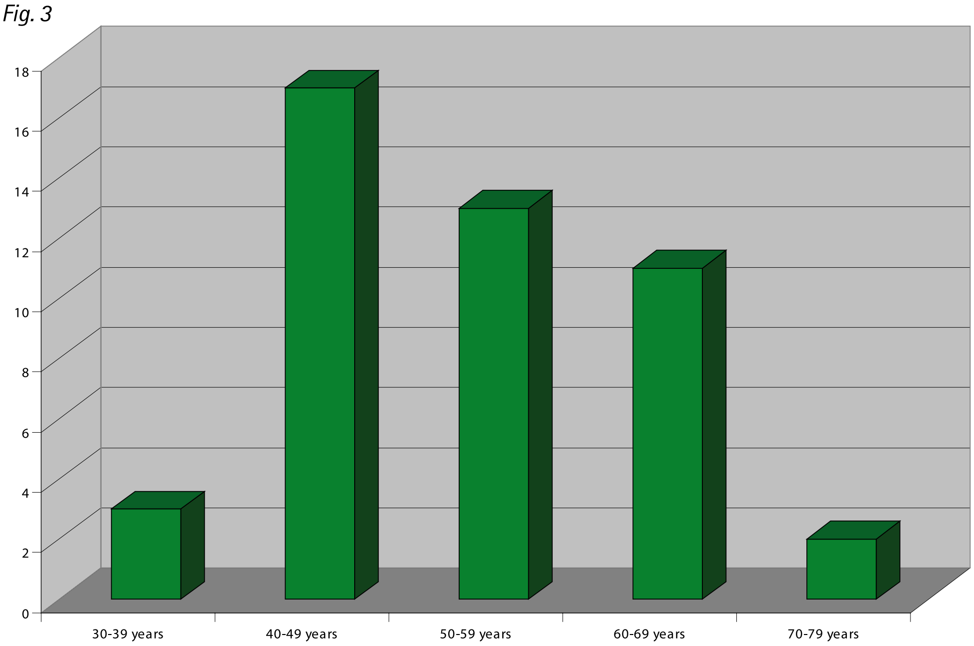


Fig. 3



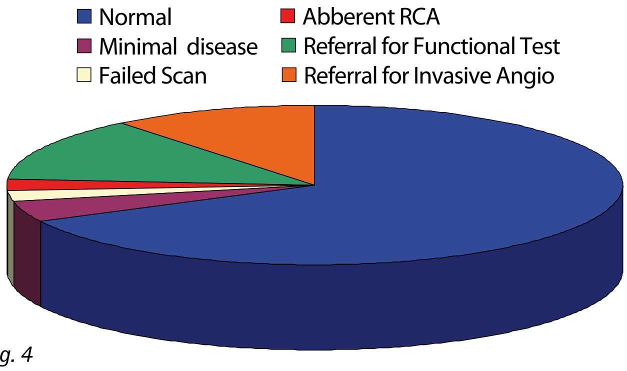


Fig. 4

ment attendances with chest pain per year equating about 25 admissions per day with approx. 75% being admitted. 35% of these patients reattend with similar symptoms within a 12 months period.

In our current investigation pathway patients who present with chest pain are typically risk stratified with an appropriate history and physical, and ECG, chest X-ray and laboratory studies including cardiac biomarkers. However unfortunately these investigative tests have several limitations: ECG is diagnostic of acute myocardial infarction in only 40%-65% of patients[5]. Serum markers for myocardial necrosis detect only approx. 70% of patients with acute myocardial infarction on arrival[6]. Because of this diagnostic difficulty physicians have a low threshold for admitting patients with chest pain in whom the diagnosis is not immediately clear. Approximately 65% of these patients however have an eventual diagnosis of non-cardiac chest pain.

One risk stratification tool that is widely used in emergency departments is the Thrombosis in Myocardial Infarction (TIMI) risk score that predicts the triple endpoint of death, new or recurrent myocardial infarction (MI), or need for urgent target vessel revascularization within two weeks of presentation. The TIMI risk score includes:

- Age >65 years
- History of known coronary artery disease (documented prior coronary artery stenosis >50%)
- >3 conventional cardiac risk factors (age, male, sex, family history, hyperlipidemia, diabetes mellitus, smoking, obesity)
- Use of aspirin in the past 7 days
- ST-segment deviation (persistent depression or transient elevation)
- Increased cardiac biomarkers (troponins)
- >2 anginal events in the preceding 24 h

One point is recorded for each of the above characteristics. The score is the total number of points.

The low-risk group is defined by a score of 0 or 1 and a <5% likelihood of requiring intervention. The high-risk group is defined by a score of 6 or 7 and a 40% likelihood of = requiring intervention. This approach has been validated in a number of additional trials.

Currently in our hospital patients in the low to intermediate risk group undergo serial ECGs; cardiac enzymes and troponins and then have a further investigation: exercise tolerance test (ETT), myocardial perfusion scintigraphy, stress MRI or invasive angiography. The decision as to which of these investigations is performed next will depend upon the clinical risk profile and the degree of suspicion that the underlying chest pain will be cardiac in nature. All patients will however have some form of further investigation with an OP ETT being the most common further investigation undertaken if the patient is well and other basic tests are negative.

Change in practice

Developments in cardiac CT have offered the opportunity to change practice and to increase the diagnostic accuracy with which coronary artery disease is diagnosed at the point of first contact. There is now a significant amount of evidence to show that cardiac CT is a better test than other available tests:

Fig. 5: Right main pulmonary artery embolus

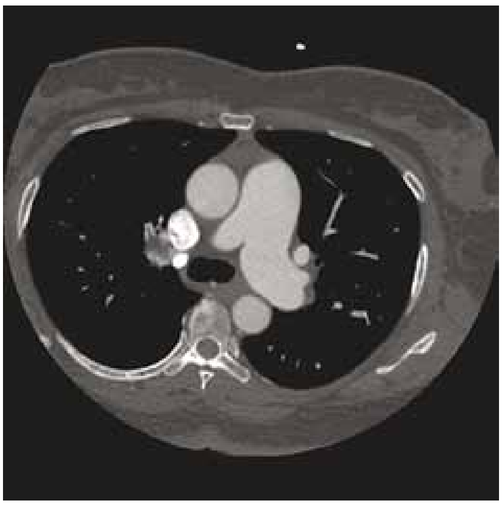


Fig. 6: Left lung - segmental artery embolus

Fig. 7: Acute bronchiolitis – apical segment left lower lobe changes

Fig. 8: Dilated ascending aorta measuring 4.2 cm in diameter

1) The NICE Assessment Report reviewed 21 studies with 100 or more patients that evaluated the sensitivity and specificity of both SPECT and stress ECG (ETT) in the diagnosis of coronary artery disease compared with invasive coronary angiography.

Median sensitivity values for SPECT were higher than those for ETT in all studies (SPECT: 81% for the largest subcategory of studies, with a range of 63–93%; ETT: 65% for the largest subcategory of studies, with a range of 42–92%).

Median specificity values were similar for SPECT (65%, range 10–90%) and ETT (67%, range 41–88%).

American College of Cardiologists/American Heart Association Task Force guideline, with average sensitivity and specificity reported as 89–90% and 70–76%, respectively for SPECT.

This demonstrates that both nuclear medicine SPECT imaging and stress exercise tolerance test imaging are suboptimal in the diagnosis of coronary artery disease.

2) Cardiac CT angiography is now sufficiently robust to be used routinely for a number of clinical applications. More than 16 published studies have compared 64-slice MDCT with coronary angiography for the detection of coronary artery stenoses. These papers, which together draw on data from 1400 patients, conclude that on average 95% of all coronary segments are fully accessible and can be compared to cardiac catheter findings. Sensitivity, specificity, and positive and negative predictive values have been reported as 85%, 96%, 85%, and 96%, respectively[7,8,9,10].

3) A head-to-head comparison between stress ECG and cardiac CT showed CT to have a significantly higher sensitivity (91% versus 73%) and specificity (83% versus 31%). CT was unable to assess 8% of patients, while stress ECG failed to evaluate 19% of study subjects[11].

4) More recently, Goldstein et al performed a randomized trial in 197 patients with acute chest pain at low risk for ACS presenting to the ED and compared the safety, diagnostic efficiency, and cost of 64-MDCT with the standard of care diagnostic evaluation.

Physicians using multidetector CT were able to immediately exclude or identify coronary disease as the source of chest pain in 75% of patients. The remaining 25% of patients required stress testing because of intermediate severity lesions or nondiagnostic scans.

The patients who underwent multidetector CT had a safety profile (no adverse coronary events for 6 months) equal to that of patients treated with the standard of care approach.

Initial evaluation with multidetector CT reduced diagnostic time to an average of 3.4 hours compared with an average of 15 hours with a standard of care evaluation.

Average cost per patient was lowered from $1872 to $1586 when the multidetector CT algorithm was used.

Patients in the multidetector CT arm of the study also required fewer subsequent evaluations for recurrent chest pain.

5) In March 2010 new guidelines by the National Institute for Health and Clinical Excellence (NICE) were published, Chest pain of recent onset: Assessment and diagnosis of recent onset chest pain or discomfort of suspected cardiac origin. According to these guidelines in patients with suspected angina where there is an estimated likelihood of coronary artery disease of 10-29% calcium scoring/cardiac CT are the "first-line diagnostic investigations".

6) There is also evidence that a "better" CT scanner means better images. A study presented at RSNA in 2008 analyzing the diagnostic performance of scanners with different numbers of rows of detectors showed a significant improvement in accuracy[12].

Image quality was rated poor for the following percentages of coronary artery segments: 33.1% at four-slice CT, 14.4% at first-generation 16-slice CT, 6.3% at second-generation 16-slice CT, and 2.6% at 64-slice CT.

Sensitivity, specificity, PPV and NPV, respectively, were as follows: 57%, 91%, 60%, and 90% at four-slice CT; 90%, 93%, 65%, and 99% at first-generation 16-slice CT; 97%, 98%, 87%, and 100% at second-generation 16-slice CT; and 99%, 96%, 80%, and 100% at 64-slice CT.

So there is good evidence now that ETT has poor sensitivity in the detection of coronary artery disease and that cardiac CT is more sensitive than ETT; more sensitive and specific than SPECT with a considerably lower dose profile and cost; has the potential for cost and time savings – and ought to be the new first-line investigation in the low/intermediate risk group. In addition better scanners appear to be of greater diagnostic performance.

The purpose of our study was therefore to determine how to integrate this new technology into our chest pain pathway. Heart of England NHS Foundation Trust is the first UK institution to offer volume cardiac CT (VCCT) scanning of chest pain admissions via the accident and emergency department. We present data from the first 3 months of this trial novel chest pain management pathway.

Methods and materials

All patients presenting via the accident and emergency department in whom there was a strong clinical suspicion of coronary artery disease and who met strict inclusion and exclusion criteria were potentially eligible to have a VCCT.

Inclusion criteria
- Strong clinical suspicion of angina
- No acute ECG changes
- Negative troponin (initial)
- No known history of coronary artery disease
- Age <70 years and >35 years (male), >40 years (female)
- BMI <38
- TIMI Score of low or intermediate - < or = 4

Exclusion criteria
- Positive troponin
- ECG changes
- Creatinine eGFR <40
- Known coronary artery disease
- Severe asthma/aortic stenosis/LVF

All patients initially underwent standard investigations for chest pain: history; examination; bloods including cardiac enzymes and troponin T; and an ECG. If all these investigations were negative but there was still a suspicion that the pain was cardiac in origin the patient was eligible for a VCCT. Patients were given an OP appointment to return for a VCCT rather than the existing protocol of having an OP ETT.

All cardiac CTs were carried out with a Toshiba Aquilion ONE CT scanner. A volume cardiac CT was performed on this 320-row CT system which allows up to 16 cm of z-coverage which means that the whole heart can be imaged in a single, non-helical rotation (0.35 s). Patients were positioned on the couch supine, with head first and were asked to hold their breath for approximately 3-4 s for the duration of the scan. The scan was optimized by attempting to reduce the patient's heart rate using the IV β-blocker metropolol. It was titrated up in 10 ml aliquots as required in order to reduce the heart rate to below 65 beats per minute (bpm). β-blockers however were avoided in patients with one or more of the following contraindications:
- Asthma
- Sinus bradycardia
- Hypotension: BP <90 systolic
- Overt heart failure
- Cardiogenic shock
- 2nd or 3rd degree block
- Right ventricular failure secondary to pulmonary hypertension

Further image optimization was performed by using 500 micrograms of sublingual GTN.

70 mls of Optiray 350 strength contrast was used. A variable sliding scale of kV and mA is used depending on the patient's BMI. The purpose of using a sliding scale is to obtain the best quality images while giving the patient the lowest dose. For patients with a BMI <28, a 100 kV technique is used while patients with BMI of 28-35 use a 120 kV technique and patients with BMI>35 use a 135 kV technique.

Fig. 9: Active sarcoid – subcarinal and right hilar lymphadenopathy is demonstrated

Fig. 10: Active sarcoid – peripheral nodules (arrow)

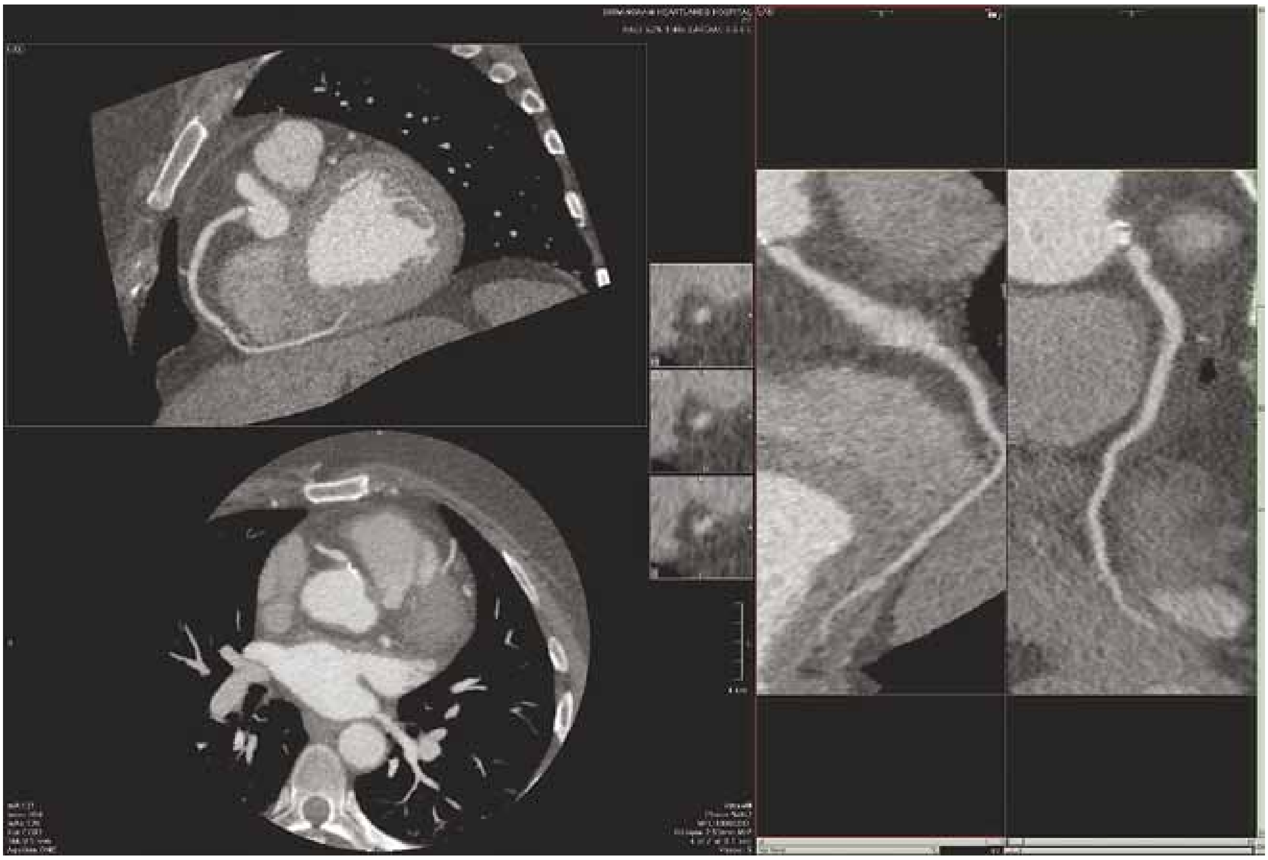


Fig. 11: Cardiac CT image demonstrating an ostial RCA stenosis

The scan is triggered by bolus tracking of contrast in the ascending aorta. A dual injector is used with an initial 100 mls of 350mg/ml iodine concentration contrast at a rate of 5 ml/s followed by a 15 ml saline chaser at the same rate. This is injected via a 21G cannula sited in the right anticubital fossa. When attenuation within the ascending aorta is at the level of 180 HU the VCCT is initiated after a breath-hold command.

Reconstructions were performed at 75% of the R-R interval and then 3% above and below this level allowing for analysis of 3 sets of data. Data was reconstructed at a slice thickness of 0.5 mm. Reconstruction of the width of the chest covered using a lung kernel was also performed. Data was transferred to a Vitrea workstation and was analyzed by a consultant cardiothoracic radiologist.

Results

46 patients in total were referred from the accident and emergency department and underwent a VCCT. Of these 63% were male and 37% were female (Fig. 1). 70% were Caucasian and 30% were of south Asian origin (Fig. 2). Average age was 61 years. Age distribution is shown in Figure 3.

The results of the VCCTs are shown in the following table:

Normal	31
Minimal disease	2
Failed scan	1
Aberrent RCA	1
Referral for functional test	6
Referral for invasive angio	5

Significant coronary artery disease (normal/minimal disease) was excluded in 72% (Figure 4). However an alternative pathology was identified in 7 of the patients in this group. These included:

- Pulmonary emboli (Figures 5, 6)
- Acute bronchiolitis (Figure 7)
- Dilated cardiomyopathy
- Dilated ascending aorta approx. 4.2 cm (Figure 8)
- Active sarcoidosis (Figure 9,10)
- Bronchiectasis
- AVMs

Six patients with mild or mild-moderate disease, the functional significance of which was uncertain, were referred for functional testing. In this group:

- 1 patient had a normal exercise tolerance test, i.e. non-functional stenosis, and was managed medically
- 1 patient had a normal stress MRI, i.e. non-functional stenosis, and was managed medically

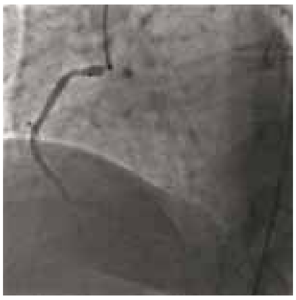


Fig. 12: Invasive angiogram image confirming RCA ostial stenosis

Fig. 13: Invasive angiogram image confirming RCA ostial stenosis

Fig. 14: Invasive angiogram image showing angioplasty and stent insertion

Fig. 15: Invasive angiogram post procedural image shows a good result

- 2 patients were reviewed in clinic and it was decided to try medical management
- 2 patients did not attend for follow up

Five patients with severe/ moderate to severe disease or with heavy calcified atherosclerotic plaque that made interpretation of the cardiac CT difficult were referred for invasive angiography. In this group:

- 2 patients had disease confirmed and underwent angioplasty (Figures 11-15)
- 1 patient had disease confirmed and was listed for a coronary artery bypass graft (CABG)
- 2 patients had disease overestimated by cardiac CT and it was decided to initially try medical management

Conclusion

72% had no coronary artery disease and were therefore given a definitive diagnosis of no CAD. There were no readmissions at the 6 months follow-up which shows:

- cardiac CT is a robust accurate test with a high negative predictive value
- by giving a definitive diagnosis it reduces unnecessary representation to A&E

Of these, however, 21% had some other, frequently significant pathology to explain their presenting symptoms, including pulmonary embolus, aortic dissection, acute bronchiolitis, active sarcoid. These life threatening pathologies would not be identified on other "cardiac" tests. Thus VCCT allows for identification of alternative pathologies to explain the patients symptoms which other tests such as ETT, MIBI, stress MRI and invasive angiography would miss.

13% had mild or moderate disease and were referred for functional testing, that is ETT. Of these no patients progressed to angiography, i.e. the test was considered "normal". Previously these patients would have been discharged with a diagnosis of non-anginal pain, i.e. no CAD. However cardiac CT has shown that they all have CAD which although not functionally significant requires lifestyle modification and secondary prevention. This certainly will have a public health benefit.

11% had severe disease and went onto invasive angiography of which 7% underwent revascularisation (2 angioplasty and stent and 1 CABG). Again the other 4% need lifestyle modification and secondary prevention and again this will have a public health benefit.

VCCT, therefore, has been shown to be a low dose test which, when available in the emergency department, can give a definitive diagnosis of coronary artery disease. The test has a negative predictive value of close to 100%. Since it identifies non-functionally significant coronary artery disease there are likely to be benefits to the health economy in general through preventative measures. The other potential benefit of VCCT offered as a first-line investigation is the fact that it obviates the need for an overnight bed stay or for a serial cardiac enzymes/troponin. This would significantly reduce cost and patient inconvenience.

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cardiac CT@lumc

2-day workshop

8 & 9 December 2011

Venue: *Leiden University Medical Center, Department of Radiology, Von Ronnenzaal K2-052,*
Albinusdreef 2, 2333 ZA Leiden, The Netherlands

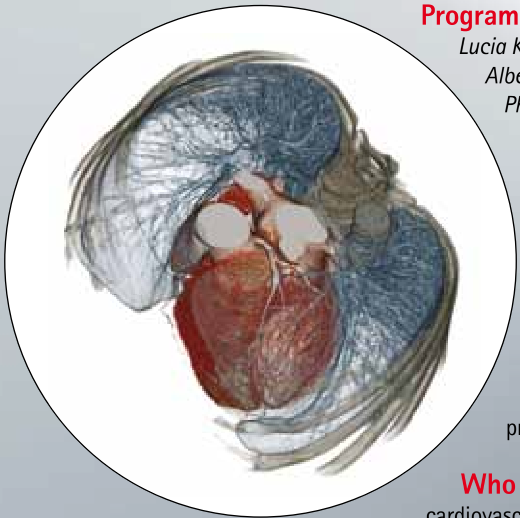
Preliminary Programme

Day 1

10.00	Opening and introduction
10.00 - 10.45	Introduction cardiac imaging
10.45 - 11.30	Basic principles of MDCT and cardiac CT
11.30 - 11.45	Coffee break
11.45 - 12.30	Scan procedures in Cardiac MDCT and possible pitfalls
12.30 - 13.15	Lunch
13.15 - 14.00	Evaluation of coronary artery MDCT: anatomy & stenosis
14.00 - 16.30	A: Patient scanning and case reading B: Hands-on & image processing on workstations
19.00 - 22.00	Social event

Day 2

09.30 - 10.15	Evaluation of coronary artery MDCT: stents, bypasses and artifacts
10.15 - 11.00	How to achieve high quality "frozen" images
11.00 - 11.15	Coffee break
11.15 - 12.00	How to make a clinical report on MDCT coronary angiography
12.00 - 12.45	CT/MRI function/perfusion in CAD
12.45 - 13.30	Lunch
13.30 - 16.00	A: Patient scanning and case reading B: Hands-on & image processing on workstations



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Background:
The purpose of this workshop is to acquire a working knowledge of current 64-row MDCT for cardiovascular imaging. Latest developments in dynamic volume CT (Aquilion ONE) will be discussed. State-of-the-art lectures on the basics of current MDCT technology as well as current clinical applications will be provided. The workshop is given in English and is limited to only 20 participants to enhance interaction between speakers and audience. In addition, hands-on training at state-of-the-art Toshiba CT scanners will be provided for small groups of participants. This includes understanding the scan procedure and the set-up for cardiovascular imaging. Furthermore, protocols will be discussed as well as the interpretation of images using hands-on training at Vitrea workstations with the latest software.

Who should attend: Radiologists, cardiologists and other physicians with an interest in cardiovascular CT, residents in training, technologists, and physicists.

Fee: € 850 for the 2-day course. This includes a hand-out, coffee, lunches and a social event. Hotel is not included.

For further details such as registration and payment instructions please contact: Secretariat workshop, Leiden University Medical Centre
Department of Radiology C2-S, Leiden, The Netherlands
Phone: +31 (0)71 526 29 93, Fax +31 (0)71 524 82 56

CME credits: Accreditation is provided by the Dutch Society of Radiology and Dutch Society of Cardiology

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