ADVANCED SERVER-BASED DIAGNOSTIC IMAGING AND POST-PROCESSING WORKFLOW AT EUROPEAN CENTRE OF HEALTH OTWOCK, POLAND

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We present state of the art diagnostic imaging modalities and the latest trends in post-processing of clinical images implemented at the European Centre of Health Otwock, Poland. Clinical images are presented as well as chosen application examples of the IntelliSpace Portal thin client/server solution. Radiologists can access any post-processing applications virtually anywhere instead of waiting for a particular workstation to become available. The Centre specializes in oncology, urology and cardioangiology and welcomes medical staff for advanced training courses as well as patients seeking high-end diagnostic and therapeutic procedures. The patients are kept at the center of what we do, as behind every image – there is a patient.

Key words: radiology, magnetic resonance, computed tomography, image post-processing.

РОЗШИРЕНА ДІАГНОСТИЧНА ВІЗУАЛІЗАЦІЯ НА БАЗІ СЕРВЕРА І ПОСТ-ОБРОБКИ WORKFLOW ПРИ ЄВРОПЕЙСЬКОМУ ЦЕНТРІ ОХОРОНИ ЗДОРОВ'Я ОТВОЦКА, ПОЛЬЩА

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Ми представляємо новітні дослідження в галузі діагностичних методів візуалізації та сучасні тенденції в наступних описах клінічних зображень, виконаних в Європейському Оздоровчому Центрі м. Отвоцк, Польща. Наведено випадки клінічних, а також окремі приклади використання додатків IntelliSpace Portal між клієнтом і сервером. Радіологи мають віртуальний доступ до даних практично в будь-якому місці і не зобов'язані чекати їх доступності на робочому місці. Центр спеціалізується в галузях онкології, урології та кардіології і пропонує пацієнтам широкий спектр діагностичних і терапевтичних медичних послуг на найсучаснішому рівні в цих областях, крім того, пропонує широкий спектр тематичних курсів підвищення кваліфікації для медичних працівників. Пацієнти завжди знаходяться в центрі того, що ми робимо.

Ключові слова: радіологія, магнітний резонанс, комп'ютерна томографія, зображення пост-обробки.

РАСШИРЕННАЯ ДИАГНОСТИЧЕСКАЯ ВИЗУАЛИЗАЦИЯ НА БАЗЕ СЕРВЕРА И ПОСТ-ОБРАБОТКИ WORKFLOW ПРИ ЕВРОПЕЙСКОМ ЦЕНТРЕ ЗДРАВООХРАНЕНИЯ ОТВОЦКА, ПОЛЬША

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Мы представляем новейшие исследования в области диагностических методов визуализации и современные тенденции в последующих описаниях клинических изображений, выполненных в Европейском Оздоровительном Центре г. Отвоцк, Польша. Просмотр изображений клинических, а также отдельные примеры использования приложений IntelliSpace Portal между клиентом и сервером. Радиологи имеют виртуальный доступ к данным практически в любом месте и не обязаны ожидать их доступность на рабочем месте. Центр специализируется в областях онкологии, урологии и кардиологии и предлагает пациентам широкий спектр диагностических и терапевтических медицинских услуг на самом современном уровне в этих областях, кроме того предлагает широкий спектр тематических курсов повышения квалификации для медицинским работников. Пациенты всегда находятся в центре того, что мы делаем.

Ключевые слова: радиология, магнитный резонанс, компьютерная томография, изображение пост-обработки.

INTRODUCTION

European Centre of Health Otwock (ECH, Otwock, Poland) is the only private hospital in Poland that includes three academic clinics: Oncology, Urology and Cardioangiology. The clinics are part of the Polish Medical Centre of Postgraduate Education (CMKP).

The hospital is equipped with a state of the art diagnostic imaging modalities that include: 3-Tesla Magnetic Resonance (MR) Philips Achieva 3T TX (first in Poland 3T MultiTransmit system with 32 RF channels), 128-slices Philips Brilliance iCT SP Computed Tomography (CT),

Hologic Selenia Dimensions 3D Mammography with breast tomosynthesis and many more ulta-modern systems.

As the Diagnostic Imaging Department provides imaging capabilities at the highest academic level, the image data load is extensive.

For example in just one of the modalities – MRI, about 3000 scans are performed, mainly for oncology and cardiology inpatients, as well as a wide variety of outpatient scans. Examples of technically advanced 3T MRI images are presented on Fig. 1 and Fig. 2, a, b.
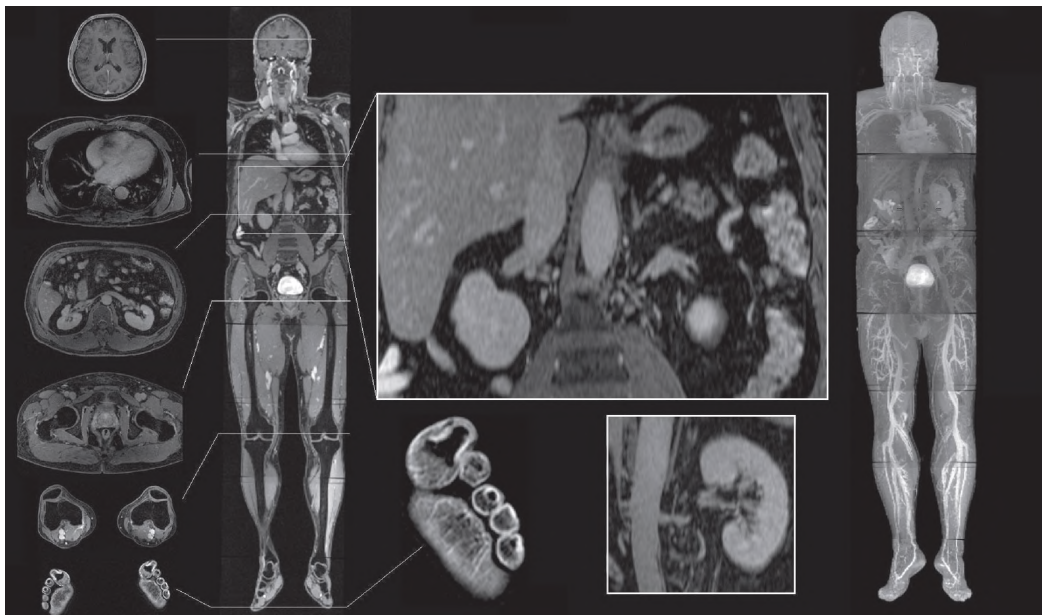
Fig. 1. Whole Body 3T MRI performed with a custom-made imaging protocol on Philips Achieva 3T TX scanner in ECH Otwock. The original 1200 axial crossections of 1.7 mm thickness (left) are post-processed and reformatted using advanced algorithms allowing a 3-dimentional assessment in any plane.

a

b
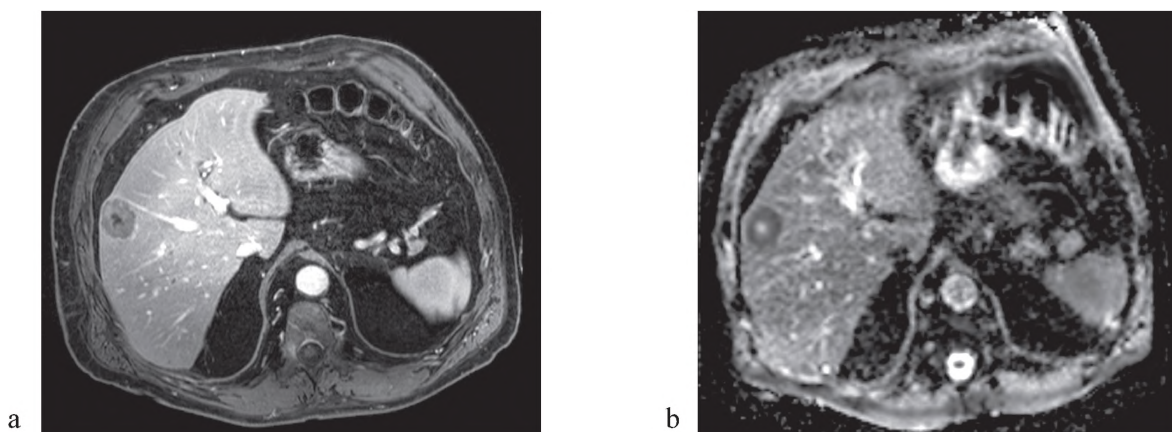
Fig. 2, a, b. Metastase of rectal cancer to the liver.
a) 3T MRI T1-weighted image post paramagnetic contrast agent (Gadolinium) administration (left).
b) 3T MRI apparent diffusion coefficient (ADC) map presenting diffusion restriction in metastase but not in it's nectrotic core.

Modern imaging protocols, especially from MRI and CT, result in thousands of images per patient in each examination. Thus the post-processing and robust handling of diagnostic image data plays a significant role in everyday clinical practice.

PORTAL SOLUTION

European Centre of Health Otwock was the first hospital in Poland to introduce the "Portal Server" solution in the advanced multi-modality Diagnostic Imaging Department. Initially already in 2010 the "Brilliance Portal Server" was installed together with the Philips iCT SP 128-slices computed tomography scanner. Beeing an International Philips Healthcare Reference Centre, ECH Portal solution was upgraded to the latest IntelliSpace Portal version, that gives remarkable possibilities in the field of diagnostic image post-processing and medical image analysis.

Referring physicians are relying on radiologists to provide a confident diagnosis. Their treatment plan depends on the analysis and report. The clinical information can be quickly and easily shared among doctors taking care of the patient.

Extensive clinical coverage plays a key role, but there are also other dimensions to delivering the confident diagnosis: special tools and efficient workflows allow to concentrate quickly on relevant images.

The radiology IT systems and applications must keep evolving to help radiologists adopt the latest clinical advances.

Growing numbers of images per patient and multi-modality cases overall mean the need for an enormous amount of data to review. Automatic image enhancement tools, allow to focus on what is needed and visualizations, such as graphs and color-coded maps, present the quantified data that are easy to interpret.

By taking steps to achieve definitive diagnoses, the new radiology post-processing systems lay the foundation for developing tailored treatments and improving patient care. Armed with clinically relevant information, the doctors can provide patients with the input to treatment planning they need.

IntelliSpace Portal is an advanced visualization and analysis solution to open these dimensions – virtually anytime and anywhere. It's designed to give a comprehensive clinical view while helping to work fast and with increased diagnostic confidence.

IntelliSpace Portal is built on client-server architecture (Fig. 3). It securely streams CT, MR, molecular imaging (MI), and ultrasonography (US) images directly to a client of the choice (such as a PC, laptop, or picture archiving and communication system (PACS)) over a broadband connection through the hospital's virtual private network.

Radiologists can access, review, analyze, diagnose, and present images quickly, efficiently, and collaboratively with the latest technology with a single advanced visualization and analysis tool. It works across clinical specialties, across modalities, and across the enterprise of the European Centre of Health.
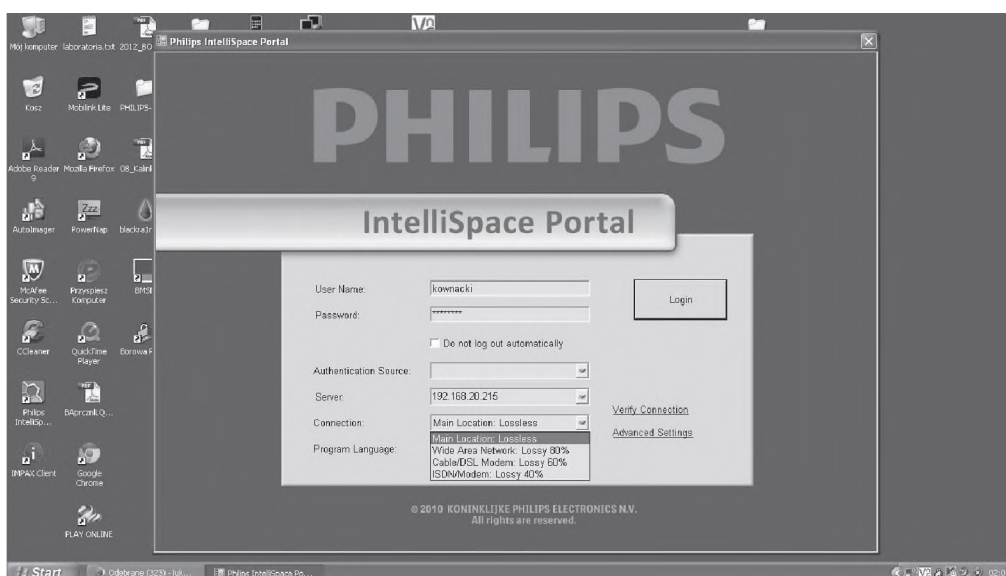
Fig. 3. Login screen of IntelliSpace Portal application installed on a Microsoft Windows system. Before the start, user can choose the monitors mode (2 monitor configuration is available) as well as optimize the image compression options to the available network band. Before the login an extensive network connection test can be performed with a single click.

IntelliSpace Portal can transform the way radiologists work and care for patients. This single multi-modality and multi-vendor advanced visualization and analysis system gives the measurement and quantification capabilities to support efforts in diagnostic objectiveness and consistency like never seen before.

Rich and growing portfolio of IntelliSpace Portal applications with automated image optimization as well as image selection make it easy to focus on what matters most in particular cases (Fig. 4).

As the IntelliSpace Portal is a tool which evolves continuously, the radiologists are well-equipped for the future diagnoses. The built-in access automatic software updates, IntelliSpace Portal always offers superb means for image posprocessing.
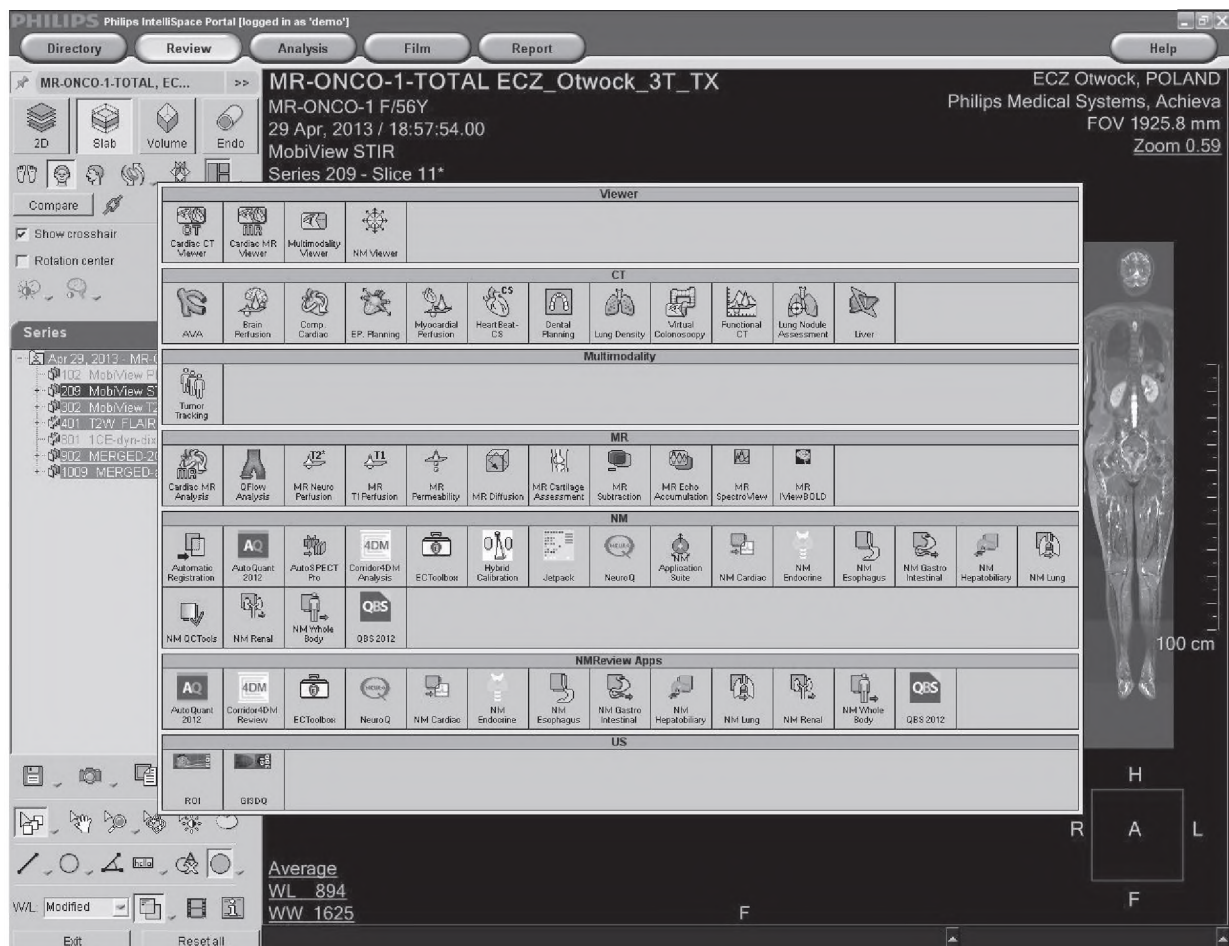

Fig. 4. An extensive list of IntelliSpace Portal applications presented after case/series selection.

The installed thin-client software automatically upgrades itself whenever the main server is upgraded. This takes usually just a few minutes and requires no interactions from the user. Thus all the workspots using Portal don't have to be taken care of when major upgrade is performed as it only "physically" affects the main server. The server automatically spreads the latest version of diagnostic tools at client login.

Radiologists enjoy one unified view of patient and can instantly access, review, analyze, diagnose, and present CT, MR, and MI (molecular imaging) images along with US viewing virtually anytime and in any place in the hospital and outside of it.

All of this can be accomplished right from any networked computer or directly from the PACS – thanks to a single solution that connects to the radiology department network via a powerful, all-in-one applications server.

For example, Portal clients are installed at the operating rooms of ECH, providing an instant access to any image posprocessing capabilities even during the operation.

The Web Collaboration solution enables viewing and sharing with tablets and smartphone devices – however not intended for diagnosis, only for reference purposes.

Radiologists aren't tied to modality workstations, and are free to access images from virtually anywhere – office

PC, home laptop, and even a tablet device. This enables to share images and results with peers, specialists, and referring physicians in real time.

The Portal creates one, unified view, linking multi-modality data from multiple vendors with ease. As a result, we can leverage the anatomical, functional, spatial, and temporal dimensions provided by CT, MR, MI and US on a single platform.

Recently the new applications were added to the continuously expanding portfolio to offer a comprehensive suite of MR applications in cardiology and neurology. New CT applications, for example, also reflect developments in transcatheter aortic heart valve (TAVI) procedure planning, myocardial perfusion assessment, and emergency care.

It is possible to explore more of every case thanks to a variety of enhanced applications in several clinical specialties. With Multi Modality Viewing we can read different neurology application results in one view. We

look forward to additional portfolio enhancements in future releases.

CARDIOLOGY
IntelliSpace Portal cardiology applications consist of:
CT Advanced Vessel Analysis Stenosis
CT Advanced Vessel Analysis Stent Planning
CT Cardiac Viewer
CT Comprehensive Cardiac Analysis (Fig. 5)
CT-NM Cardiac Fusion
CT Calcium Scoring
CT Cardiac Plaque Assessment
CT TAVI Planning
CT EP Planning
CT Dynamic Myocardial Perfusion (DMP)
CT Myocardial Defect Assessment
MR Cardiac (Fig. 6)
MR Cardiac Temporal Enhancement
MR Cardiac Whole Heart
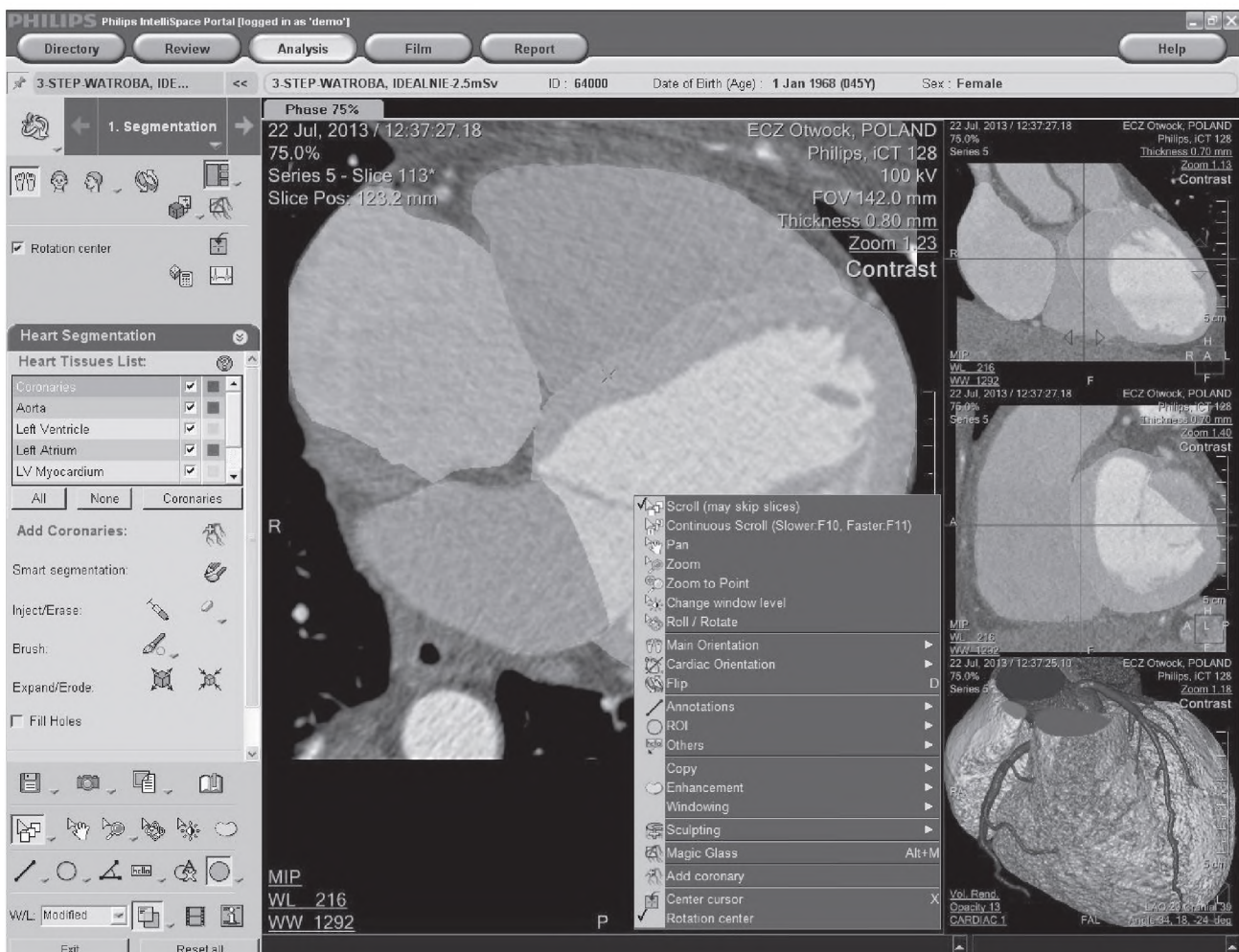
Fig. 5. "CT Comprehensive Cardiac Analysis" – the fully automated segmentation tool transforms the heart into individual segments within seconds.
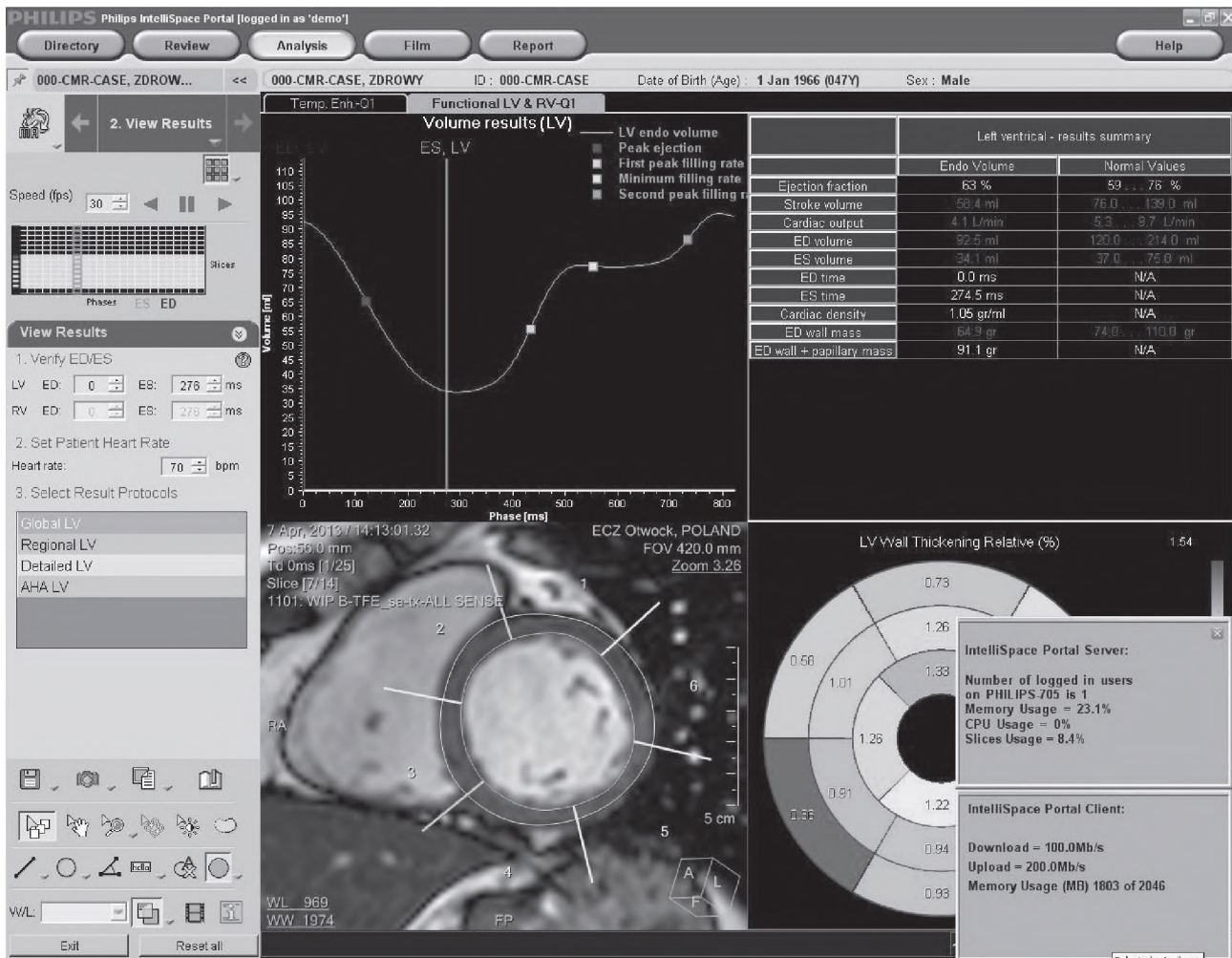
Fig. 6. "MR Cardiac" – comperhensive cardiovascular magnetic resonance tool for quantitative ventricular analysis and other advanced cardiac MR post-processing. Client-Server connection speed is tested (lower right corner) in the hospitals local network.

MR QFlow (Fig. 7)
NM Review
NM Astonish Reconstruction
NM Processing Apps Suite
NM AutoQUANT SPECT
NM AutoQUANT
Cedars-Sinai Cardiac Suite
NM Cedars MFSC (multi-frame secondary capture)
NM SPECT Corridor4DM
Corridor4DM
Corridor4DM – CT Option
NM Emory Cardiac Toolbox (ECTb) SPECT
NM Emory Cardiac Toolbox (ECTb) PET
NM Emory Cardiac Toolbox (ECTb) NM
NM Emory Cardiac Toolbox (ECTb) Heart Fusion
NM Emory Cardiac Toolbox (ECTb) SyncTool
US Viewing (MMV)
Multi Modality Viewer

The expanded view in cardiology benefits from a rich suite of cardiology applications on IntelliSpace Portal. New MR advanced analysis capabilities join other rich tools for CT and MI to give a comprehensive view. Models, maps, and other visualization tools turn data into quantitative information (Fig. 6, 7).

With "CT TAVI Planning" application, radiologists and cardiologist can quickly assess the aortic root anatomy for pre-TAVI planning and obtain crucial information about eligibility, proper device size, and a recommendation for C-arm angle for device deployment.

The "CT Comprehensive Cardiac Analysis" (Fig. 5) advanced application provides automatic, model-based, whole heart segmentation and zero-click coronary artery segmentation, enabling automatic extraction and visualization of the entire coronary tree.

"MR QFlow" application allows to review flow in large vessels in detail (Fig. 7). The application includes overlays

with 2D color flow maps on anatomical references, automatic vessel contour detection, and the ability to bookmark the entire review for later use or for communication with other physicians.
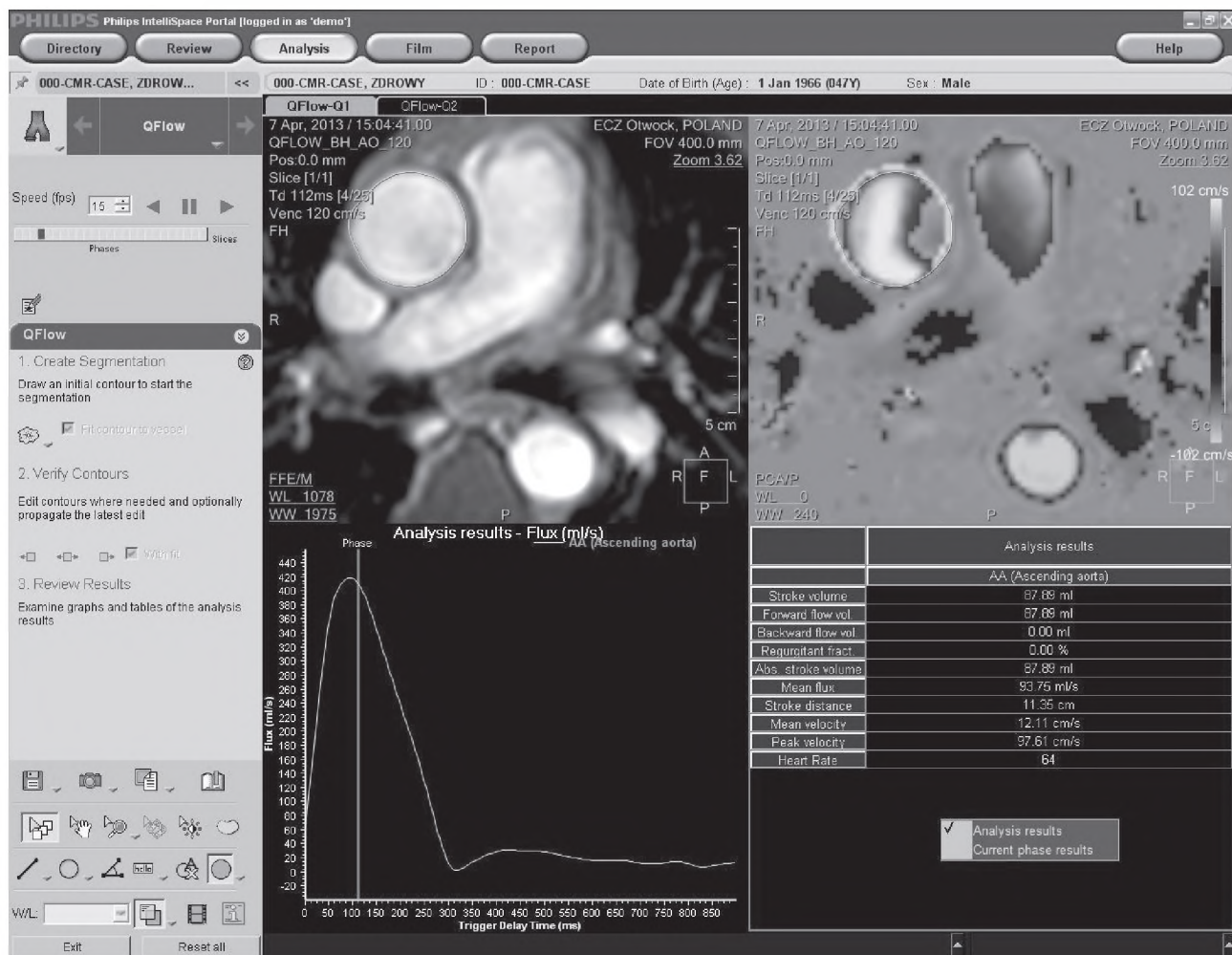
Fig. 7. "MR QFlow" – quantitative analysis of blood flow in ascending aorta.

"MR Cardiac" (Fig. 6) application enables easy visual scoring in various exam contexts. It allows to perform a functional volumetric analysis for the ventricles and segmentations to generate global functional parameters. Identification of spatial enhancement is based on intensity signal changes.

Several applications, such as CT Comprehensive Cardiac Analysis, also offer fused capabilities to offer a deeper view of each case.

NEUROLOGY

IntelliSpace Portal neurology applications include:
CT Advanced Vessel Analysis (AVA) Stenosis
CT Advanced Brain Perfusion
CT Brain Perfusion Time Insensitive Maps
CT Body Perfusion
MR Diffusion

MR T2* (Neuro) Perfusion
MR FiberTrak (Fig. 8)
MR IViewBOLD
MR SpectroView
MR Permeability
NM Review
NM NeuroQ
NM NeuroQ EQuAL
US Viewing (MMV)
Multi Modality Viewer

Comprehensive neurology MR applications join existing CT and MI capabilities on IntelliSpace Portal to help assess recoverable tissue quickly and easily. This rich suite of tools also helps to evaluate neurological degenerative diseases by, for example, analyzing FDG and amyloid uptake.

"Multi Modality Viewing" environment enables to review comprehensive and advanced MR data in the most comprehensive way possible. It uploads, for example, information from MR FiberTrak (Fig. 8) and MR IViewBOLD applications.

"CT Advanced Brain Perfusion" application calculates and displays reduced summary maps to help radiologists identify areas of salvageable tissue in acute stroke patients. It is especially helpful in time critical treatment decisions.

Key enhancements in neurology applications suite are aimed at increasing confidence. In addition to the "Traffic lights" on CT Advanced Brain Perfusion, other applications offer built-in features to support diagnosis. "MR SpectroView", for example, includes clinically driven protocols and quality indicators, while "MR FiberTrak" (Fig.8) provides guidance for fibertrak tracts.

What's more, three key modalities – CT, MR, and MI – are available on the same platform.

ONCOLOGY

The IntelliSpace Portal Tumor tracking application supports datasets from different imaging modalities including CT, MR, and PET/CT.

Key enhancements in oncology applications help to work more productively and easily thanks to task automation, such as segmentation, measurement tables, and pre-fetching of prior studies. The results are shared efficiently with referring physicians and tumor boards via tools such as bookmarks or the Web Collaboration option.

IntelliSpace Portal oncology applications include:
Multi Modality Tumor Tracking
Multi Modality Viewer
CT Virtual Colonoscopy
CT Liver Analysis
CT Lung Nodule Analysis
CT Lung Density
CT Body Perfusion
MR Diffusion (Fig. 8)

Fig. 8. Advanced diffusion / tractography package allows a state of the art post-processing of diffusion tensor images.

MR T1 Perfusion
MR Permeability
MR Subtraction
MR Spectroscopy
NM Review
NM Processing Application Suite
US Viewing (MMV)

The multi-modality suite of oncology applications on Philips IntelliSpace Portal supports radiologists with tools through the entire oncology patient cycle, from screening to treatment response evaluation.

The "Multi-modality Tumor Tracking" application (MMTT) of Philips IntelliSpace Portal provides the tools to simplify the review and analysis of multi-modality oncology datasets for tumor detection and monitoring.

The application has semi-automatic segmentation tools to facilitate 2D and 3D segmentation of tumors and lymph nodes. For instance, it allows the user to make quick bi-dimensional measurements using 2D measurements tools. The application also enables graphical tracking of the size of the tumor across the different time points.

After the measurements are completed, it automatically performs the RECIST and WHO onco-radiology scale calculations.

The MMTT application can also be used to analyze MR data. A diffusion dataset can be used to assess the size and activity of a lesion. The Apparent Diffusion Coefficient (ADC) values can be tracked as well as the size changes of the lesion.

Background:

The Post-processing of oncology (CT, PET/CT, and MR) image datasets can pose a major challenge for radiology and oncology staff. It often requires the maneuvering and analysis of a significant amount of data due to multiple follow-up studies. The user – radiologist has to:

a) load multiple patient examinations for side-by-side comparisons to the baseline scan and nadir scan (smallest criteria recorded since the treatment started) in case of new progression. These datasets often include exams from multiple imaging modalities,

b) scroll through the numerous images of large datasets to identify and locate the tumors and lymph nodes for follow-up analysis,

c) measure the size of the tumors and lymph nodes including long axis and short axis diameters, as well as other quantitative parameters such as HU values,

d) calculate tumor burden measurements based on RECIST and WHO criteria and assess response to treatment.

Response Evaluation Criteria in Solid Tumors (RECIST) is a published guideline used to assess the change in size (maximum diameter in 2D plane) of solid tumors and lymph nodes in response to therapy. The response is categorized into: Complete Response (CR), Partial Response (PR), Stable Disease (SD), Progressive Disease (PD).

The World Health Organization (WHO) criteria define shrinkage of a tumor as the decrease in the product of the largest perpendicular diameters in the largest "slice" of the tumor on a scan.

"Multi Modality Tumor Tracking" assigns labels to the lesions to distinguish target from non-target, tumor or lymph node, or marks new lesions, disappeared lesions, and major growth.

All the above actions can be semi-automatically performed by means of the "Multi-modality Tumor Tracking" application.

ORTHOPEDICS

IntelliSpace Portal orthopedics applications include:
CT Acute MultiFunctional Review
CT Bone Mineral Analysis
MR Cartilage Assessment
MR Echo Accumulation
US Viewing (MMV)

Due to an aging population and increases in obesity and sports activity, joint surgeries are on the rise. Thanks to IntelliSpace Portal tools radiologists can perform a wide variety of tasks, such as assessment and reconstruction, quickly and easily thanks to the rich orthopedics applications.

The tools are designed for even the most challenging musculoskeletal cases such as MR Cartilage Assessment.

Users can perform a complete review of the source data, verify registration and time intensity changes, and generates all types of output with or without the use of an Arterial Input Function (AIF).

CT Acute MultiFunctional Review

Radiologists can read trauma cases within one comprehensive post-processing application to diagnose trauma patients scanned with CT. It includes four stages of assessment, such as an MSK and surgical lanning stage as well as an auto-spine stage, which automatically generates multi-planar reformatting along the spinal cord and disk spaces.

Key enhancements in this orthopedics applications suite allow to take a closer look at cases involving bone and

cartilage. "CT Acute MultiFunctional Review", for example, includes an MSK and surgical planning stage.

"CT Bone Mineral Analysis", previously only available on Philips Extended Brilliance Workspace workstation, helps to track and manage degenerative and metabolic bone diseases.

Philips IntelliSpace Portal automates image processing as well as many of the manual tasks that can get in the way of delivering fast, efficient input to patient treatment. "Zero-click processing" uses a variety of automatic tools to begin preparing the case as soon as it is opened. The Portal can pre-fetch all prior studies and transfer them to a local folder with any new studies just obtained and waiting for comperative review for fast comparison.

It's worth mentioning that already for the sixth time, IntelliSpace Portal has been ranked #1 by KLAS in its "Top 20 Best in KLAS Awards: Software & Professional Services" for Advanced Visualization.

KLAS is an independent, leading research firm with the mission to improve healthcare technology delivery by honestly, accurately, and impartially measuring vendor performance for their provider partners.

SUMMARY

Today's medicine relays on high-end IT developements as the modern imaging systems flood radiologists and clinicians with enormous data load that has to be post-processed and analysed. IntelliSpace Portal is a great example of how IT can support modern medicine.

European Centre of Health Otwock is one of the most technically advanced hospitals in Poland (Fig. 9). It's goal is to provide patients with the latest imaging and treatment technologies. The advanced multi-modality Diagnostic Imaging Department with IntelliSpace Portal is also a solid base of the medical training centre.

Fig. 9. European Centre of Health Otwock – one of the most technically advanced hospitals in Poland, located near Warsaw.

The hospital is deeply involved in medical courses such as "GO WEST!" initiative. The details about the Centre and it's treatment and training offer can be foud at www.ecz-otwock.pl .

The patients are kept at the center of what we do, as behind every image – there is a patient.