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Planning and verification in radiotherapy: our experience in a filmless hospital

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In our hospital we have recently installed a new radiotherapy treatment planning and verification system. Our system allows to follow the normal clinical workflow: from patient identification to follow-up through the treatment delivery with the study of the best irradiation geometry. We designed a new technical solutions relating to the use of four linear accelerators, a Record and Verify system, a Treatment Planning System (TPS) and a clinical folder, completely paperless. All the procedures for treatment planning, setup and verification are integrated in our digital imaging long-term archive. The integration is based on the existing HL7 and DICOM standard protocols described in the International Committee and IHE RO Technical Framework, which is able to support the workflow. All the images used for planning and setup are stored in the Oncentra DICOM archive server for short-term archiving and then are sent to the Agfa DICOM long-term archive for legal and scientific purposes.

Key words: radiotherapy, planning, DICOM, IHE, integration.

Introduction

In this work our equipment reorganization experience in radiotherapy is described: from the images used for planning, to the treatment and patient follow-up. The workflow in Radiotherapy is very complicated activity and need specific set up. To use the DICOM and IHE standards is a useful choice to realize the digital procedure able to support the

radiotherapy workflow. In our hospital we reorganized the radiotherapy Department through important technological and cultural investments. The problem complexity is very high and requires specific interdisciplinary expertise.

Materials and methods

In radiation therapy planning various information datasets and functionalities are needed in order to improve the quality of the patient treatment (Table 1). Our system allows to follow the normal clinical workflow: from patient incoming to multimodality image acquisition for treatment planning and verification, to the study of the best

Table 1. Information and functionality requirements.

- Patient identification
- Clinical information
- Images for treatment planning and verification
- Treatment planning
- Multimodal image integration
  - PTV
  - Dose calculation
- Linear accelerator setup
- Patient data archive
- Cumulative dose
- Follow-up

irradiation geometry, to treatment delivery, to data and portal images archive and, finally, patient follow up. Figure 1 indicates that the radiotherapy workflow is a very complicated activity and requires a specific setup. The Figures 1a, 1b and 1c describe the radiotherapy workflow before the introduction of the new solutions. It'll be possible to modify this workflow during the next final implementation of the technological innovation. In our hospital we have installed new technical solutions related to the use of

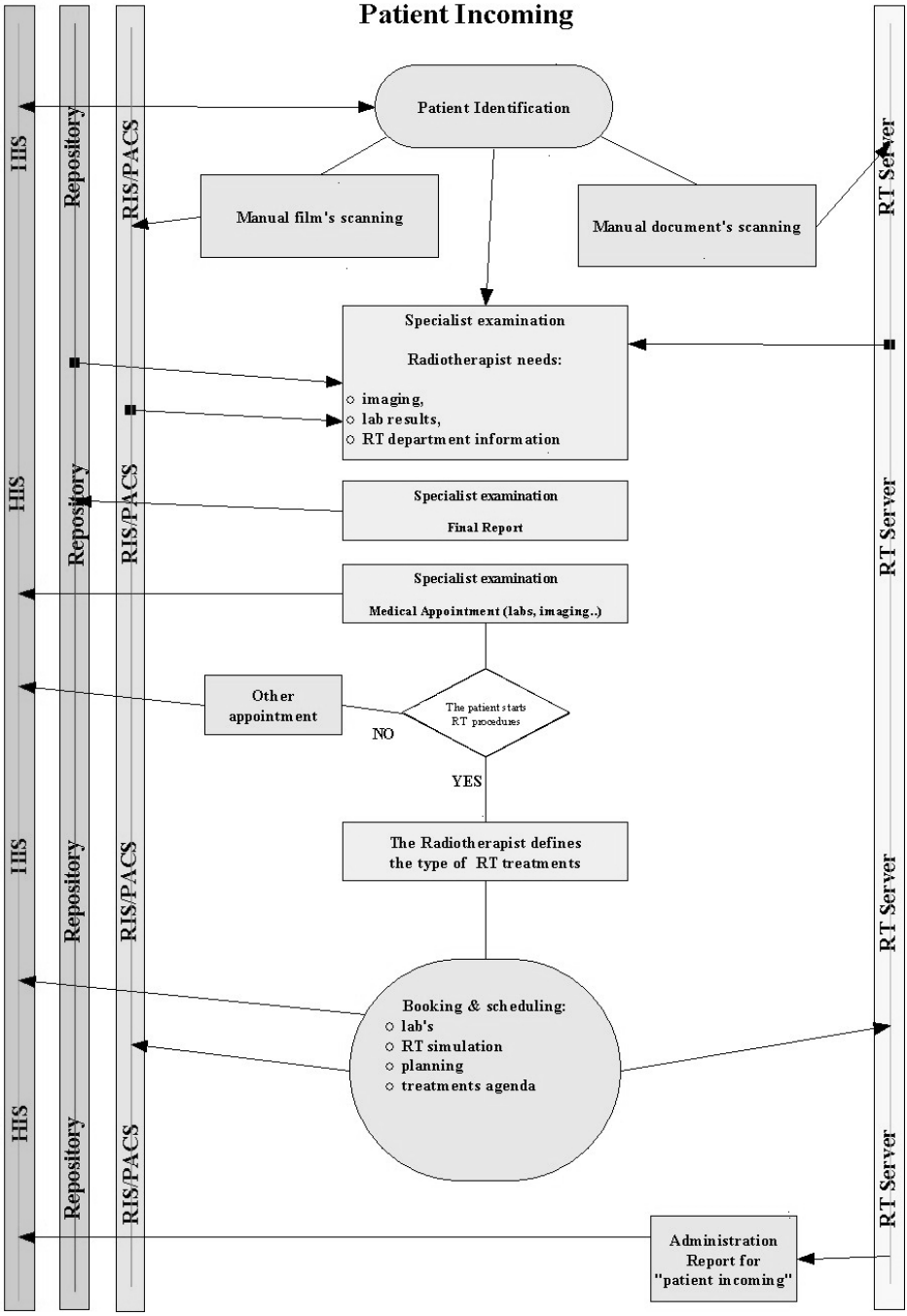


Figure 1a. Radiotherapy Workflow: patient incoming

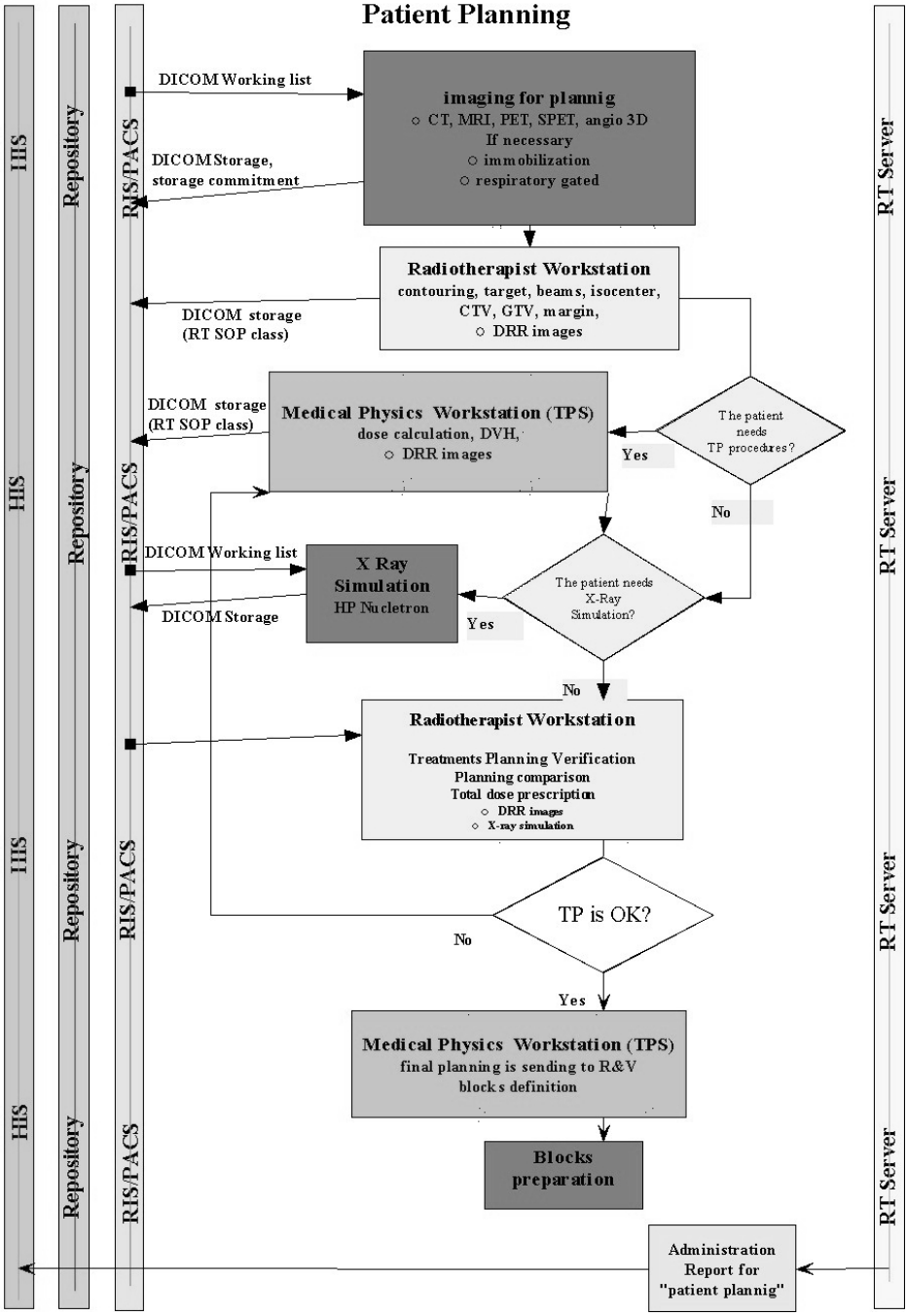


Figure 1b. Radiotherapy Workflow: patient planning

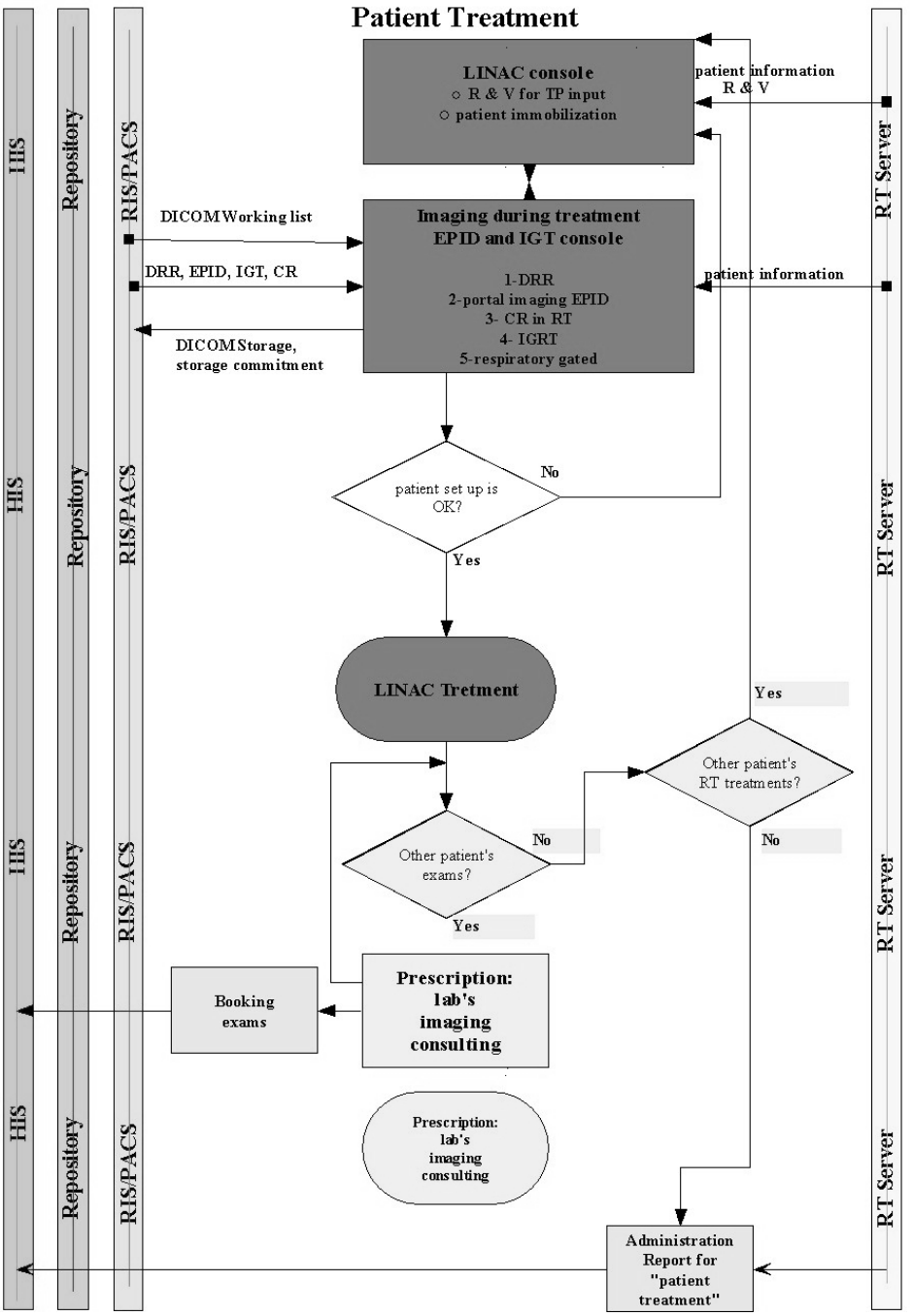


Figure 1c. Radiotherapy Workflow: patient treatment

four linear accelerators (Synergy and Synergy S, Elekta, Clinac 2100 and 600, Varian used for standard and high performed technique), a Record and Verify system (Visir, Nucletron), a Treatment Planning System — TPS (MasterPlan, Nucletron), a clinical folder (Oncentra, Nucletron) and a Gamma Knife (Perfection, Elekta) for radiosurgery (Figure 2). All the procedures for treatment planning, setup and verification will be integrated in our digital imaging long-term archive (PACS Impax Version 6, Agfa). This is already in use in the Departments of Radiology, Neuroradiology and Nuclear Medicine from 2001 (about 1.000.000 exams stored) (Figure 3); at the moment Niguarda is a filmless hospital: all the patients' images are electronically readable from each hospital department.

The integration is based on the existing HL7 and DICOM standard protocols described in the International Committee [2]. All images needed to define the treatment plan are imported into MasterPlan TPS from PACS (i.e., diagnostic and planning CT,

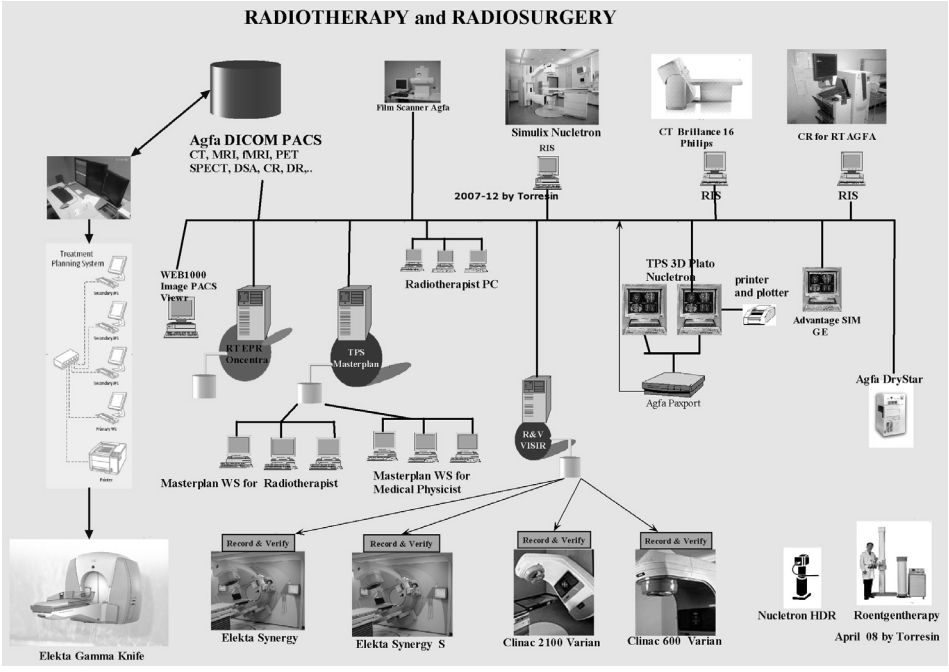


Figure 2. All the radiotherapy technologies are in network: from the entry of the patient one, during the treatment and for the patient follow up. The images useful for Radiotherapy treatment come from PACS or are produced inside the Radiotherapy Dep.; all these data are stored in according to the DICOM/IHE standards

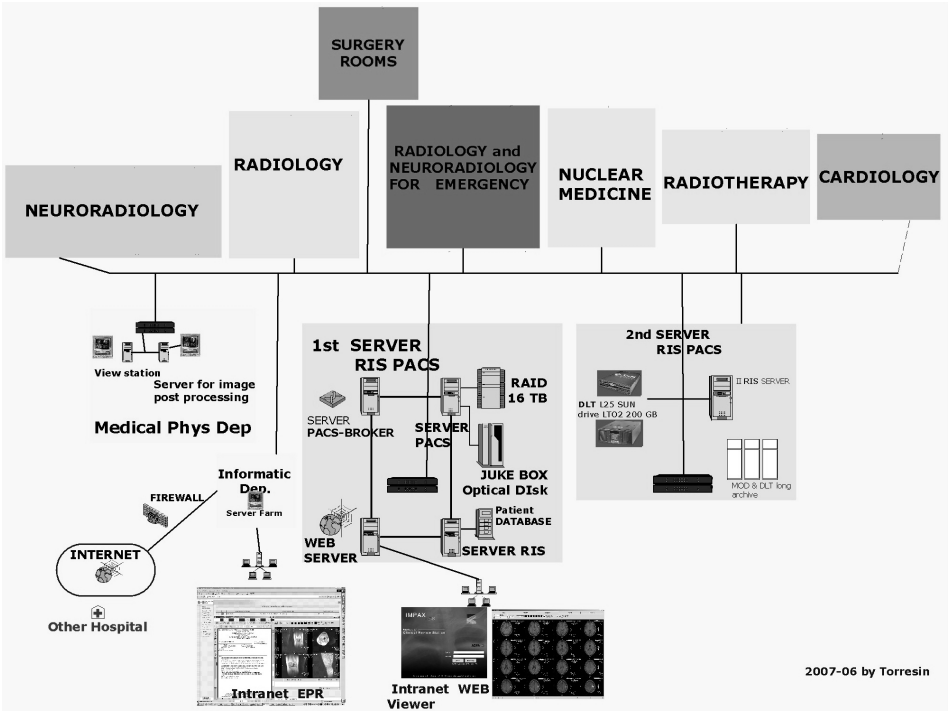


Figure 3. Scheme of the Niguarda Ca' Granda PACS archive able to store all the Niguarda digital images produced and able to create electronic image folder for each patient

MRI, fMRI, CT/PET, CT/SPECT, angiography) and from dedicated Radiotherapy CT. The approved plan is sent, by means of a defined workflow, from MasterPlan to the linear accelerators by Visir. Portal imaging (EPID images by IViewGT, Elekta) is used for 2D patient setup whereas X-ray 3D cone beam CT (XVI, Elekta) is used for 3D patient setup. All the images used for planning and setup are stored in the Oncentra DICOM archive server for short-term archiving and then are sent to the Agfa DICOM long-term archive for legal and scientific purposes.

For the most important images used in Radiotherapy (CT, PET, MRI for examples), we verified the quality of the produced images, the correct acquisition way for planning and dose calculation. This is very important to define correctly the target, which remains the most important source of error in radiotherapy. Anatomical imaging with CT and MRI generates different gross tumour volumes. Functional imaging with modalities

such as PET too will generally reveal a different volume [1]. Special attention was paid to the TPS and to the images archives.

Phantoms with geometrical and anatomic features able to simulate the clinical work conditions were used: anthropomorphic phantom Andersen Rando [4] and cardiac phantom [3].

Results

We installed all the hardware, software and dosimetric components of the project and the integration aspects for the different steps of the patient planning, treatment and verification was tested. Specific tests were executed during the acceptance tests for the different component of the system: image quality, dosimetry, DICOM storage and retrieve (for the specific SOP class of the Radiotherapy), connectivity (archive, TPS, R&V, EPID, cone beam CT, clinical folder).

CT images: we verified the correspondence of geometrical dimension of the insert present in the phantoms and the CT number for different material.

MRI and PET images: we verified the correspondence of geometrical dimension of the phantom inserts and the accuracy of registration process with CT images.

These tests are necessary because during the clinical workflow there is not only the problem of identification of the patient but also the problem of correct managing of the images inside the different systems. All images necessary to define the treatment plan are imported into MasterPlan TPS from PACS or directly from Radiotherapy Department CT. Plan calculation and plan approval are possible by means personal login and password system with specific profile. The approved plan is sent from MasterPlan to the different linear accelerators by Visir.

We tested this process with anthropomorphic phantom (Andersen Rando):

1) Acquiring a CT images of pelvic zone of the phantom with clinical protocol;
2) Contouring a PTV, Organ at Risk and pelvic bone by radiotherapist;
3) Planning a treatment with a conformed box with MLC on Elekta Synergy accelerator;
4) Positioning of the phantom with standard device used in clinical routine;
5) Delivering a treatment with use of Record and Verify system;
6) Acquiring a portal imaging with IViewGT system and matching with DDR imported by TPS;

7) Acquiring a cone beam CT with XVI system and registration with CT images used for planning.

The process of image registration and geometrical set up of the patient (using Cone Beam CT and CT images acquired for the TPS planning) was tested with the cardiac phantom and the results are inside the system requirements.

The installation is almost completed, as well as the dosimetric verification of the TPS and the integration of the different steps of the patient management. So, we can ensure that in the patient care all required information for medical decisions is both reliable and available to healthcare professionals.

Conclusions

The new integrated technology opens new scenarios and new problems inside the Radiotherapy workflow. Not only well known medical physics problems but the new technologies affect the quality of the radiotherapeutic process and new tests must be realized. This complexity requires specific interdisciplinary expertise; these may be found in the members of different Departments: Radiotherapy, Medical Physics, Bioengineering and Informatics.

We designed and tested the integration of the information systems able to support modern healthcare institutions. In this way we may ensure that in the care of patients all required information for medical decisions is both correct and available to healthcare professionals. In our project we confirm the opportunity to follow the existing standard and integration profile. On the other end open problems need future solutions (for example LINAC DICOM working list, easy integration profile for different actors in Radiological Dep and Radiotherapy Dep.). An integrated system such as we have described is important for modern radiation therapy.

References

[1] Evan PM. Anatomical imaging for radiotherapy. Phys Med Biol. 2008; 53: R151–R191.
[2] IHE RO. Technical Framework Supplement 11 Parts 3, 4, 6. Radiotherapy Information Objects Standard 1996 and Supplement 29 Radiotherapy Information Objects Standard 1999. 2006 July.

[3] Matsunari I, Yoneyama T, Kanayama S, Matsudaira M, Nakajima K, Taki J, Nekolla SG, Tonami N, Hisada K. Phantom Studies for Estimation of Defect Size on Cardiac 18F SPECT and PET: Implications for Myocardial Viability Assessment.
J Nucl Med. 2001; 42 (10): 1579–1585.

[4] Shrimpton PC, Wall B F, Fisher ES. The tissue-equivalence of the Alderson Rando anthropomorphic phantom for X-rays of diagnostic qualities.
Phys Med Biol. 1981; 26: 133–139.