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Sharing Knowledge and Integrated Information in Therapeutic Radiological Physics

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Abstract

In this paper a framework for Sharing Knowledge and Integrated Information in Radiotherapy (SKIIR) for medical physicists involved in Therapeutic Radiological Physics is discussed. The proposed SKIIR is mainly designed for sharing knowledge based on specific cases of treating patients with cancer. Integrated Information and Knowledge are captured for storing knowledge and medical information related to the specific cases of interest, in any useful form and format, for the medical physicists. Various patient cases’ descriptions and related documents of primary interest for the medical physicists are stored and organized for future use in a multimedia library including short descriptions, radiotherapy planning, ultrasound, CT and MRI images, statistical information, bibliography, discharge letters, etc. Codification of knowledge and preservation of anonymity is also discussed.

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1. Introduction

Information and Knowledge have always been important assets for health organizations. There is a significant difference between them: Information could be seen as the interpreted data and knowledge as information to be transformed into capability for effective action. Therefore, Knowledge represents the purposes for which we use information and ‘another way of looking at this is to say that information is data in context, while knowledge is
information in context’ (Gunderman and Chan, 2003). By ‘knowledge’ organizations generally imply codified information with a high proportion of human value-added, including insight, interpretation, context, experience, and so forth. It could be seen as a critical factor, empowering the organization with the ability to sustain competitive advantage. There are two types of knowledge: Tacit knowledge is embedded in the human brain and cannot be expressed, easily. Explicit knowledge can be more easily captured and codified into rules and databases. Hansen et al. believe that the idea that ‘knowledge is power’ should be taken further to mean that ‘knowledge sharing is power’ (Hansen, 1999).

Gunderman and Chan believe that in a knowledge-generating environment such as radiotherapy, ‘physicists function not in series but in parallel and the quantity and quality of their output is dependent upon interactions between the group’s members’ (Gunderman and Chan, 2003). Armoogum and Buchgeister investigate the applicability of the concept of a Radiotherapy Physics Community of Practice (CoP) (Armoogum and Buchgeister, 2010).

1.1. Sharing Knowledge and Integrated Information in Therapeutic Radiological Physics – The role of the medical physicists

The European Federation of Organisations in Medical Physics (EFOMP) founded in 1980 serves as an umbrella organisation to National Medical Physics Organisations (NMPOs) in Europe currently including 35 members and 3 affiliated members. Hellenic Association of Medical Physicists (HAMP) is the National Member Organisation for Greece. The definition of the Medical Physics given by the EFOMP is the following:

‘Medical Physics is the application of physics to healthcare; using physics for (various applications like) patient imaging, measurement and treatment. Medical physicists are graduate scientists, normally holding post-graduate qualifications, who work in many different areas of healthcare managing and delivering services and carrying out research and development. The main areas of Medical Physics include: Clinical Measurement, Diagnostic Radiology, Equipment Management, Computing, Medical Electronics, Nuclear Medicine, Radiation Protection, Radiotherapy Physics, Magnetic Resonance Imaging, Ultrasound and Non-ionising Radiation’ (EFOMP, 2013a).


In the EFOMP’s Policy Statement for the Medical Physics Education and Training in Europe and the qualifications of the Medical Physicist we can read the following: ‘Holding a university Master’s Degree in Medical Physics is not a sufficient qualification to work as a Medical Physicist in a hospital environment. To manage patients without supervision, EFOMP recommends a second part in the post-graduate training: at least 2 years’ training experience on the job. Only after completion of this training can a physicist be considered a Medical Physicist and able to work independently as a Qualified Medical Physicist. (QMP). The on-the-job training is essential to achieve the competencies to work as QMP’ (EFOMP, 2013b).

It is also worth mentioning that EFOMP has an agreement with the IAEA for the reviewing and the endorsement of documents produced by the IAEA, that fall within the scope of EFOMP.

1.2. Information and Knowledge Management

Information and Knowledge Management (I&KM) is a discipline that enables management of data, information, processes, functions, procedures, people and assets within an organization. Knowledge Management (KM) has been transformed to a core function, among top-level health companies and organizations. KM largely involves new applications based on the existing IT infrastructure. In this respect, the objectives of I&KM can be achieved by various approaches based on: techniques and tools building technical infrastructure such as information and knowledge repositories, use of classification schemes (e.g. ICD) and intelligent search that utilize ontologies, personalization techniques for dissemination of information and knowledge, tools for communicating patients’ cases, and so forth, structuring a learning organization, establishing I&KM processes, and a framework-basis for change management. Key benefits include: centralized design of organization’s rules, data and knowledge bases, improved decision making, better services, enhanced collaboration and communication, improved efficiency of
people and operations, improvement of innovation, new knowledge creation, knowledge retention, increased information and knowledge availability and access.

Information and Knowledge Management (I&KM) could be defined as the combination of Information Management (IM) aiming to facilitate data storage and processing of medical information, as well as the extraction / retrieval of information, and Knowledge Management (KM) aiming to facilitate the creation, use and transfer of knowledge. Information Management (IM) and its applications involve a wide range of themes and issues: Mining / retrieval / classification of information, Information technologies, Information Management Systems, Information ethics and legal issues, Security issues, Organizational Information Systems.

In this paper a framework for Sharing Knowledge and Integrated Information in Radiotherapy (SKIIR) for medical physicists involved in Therapeutic Radiological Physics is proposed and discussed. The remainder of the paper is organized as follows: In section 2, we present the proposed conceptual framework for knowledge sharing in the radiotherapy departments. In section 3 the methodology for Data and Information Collection and knowledge codification is given. In section 4 we test the described framework focusing on Treatment planning and Knowledge Codification. In section 5, we present our conclusions and discuss future activities.

2. A conceptual framework for knowledge sharing in the radiotherapy departments

The standard route for medical physics training in Greece differs from the ones in the UK, the German State, etc. (Armoogum, 2010). To be recognised as a medical physics expert (MPE) according to radiation protection laws in Greece requires a degree in physics or technical engineering, an accredited M.Sc. degree, a year of practical training (’Praktiki Askisi’) in the framework of the National Health System (NHS) which must include a minimum of four (4) months work with linear accelerators, and a written exam. All these qualifications form the necessary background for attaining the national medical physics certification (’Adeia’) in radiation protection for ionising radiation. During the practical training it is common for the trainees to be located in offices shared with more experienced physicists to encourage interaction. Medical physicists usually work with radiation imaging technologies to improve the treatment of patients with cancer. In this paper, we focus on medical physicists that fall into the category of Therapeutic Radiological (or Medical) Physics. Other main categories include Diagnostic Medical Physics, Nuclear Medical Physics and Medical Health Physics (AAPM, 2013).

The main activities (job duties) of the medical physicists include:

- Collaboration with radiation oncology physicians to specify the overall plans for the radiation treatments for patients.
- Treatment planning and Processing complex patient image data
- Dose calculation for radiotherapy
- Quality assurance of the radiotherapy equipments e.g. accelerators
- Undertaking audit and check of the compliance with health and safety legislation
- Radiation detection advice.
- Periodic reports of secure/safe operation of the equipments.
- Discover new treatments or improve treatments already used, researching the possibilities of new equipments and/or techniques
- Teach medical physics to technicians, medical students and young physicists

All the above activities produce a series of documents, images, etc., that are stored in different heterogeneous systems, and are valuable information for sharing only in the case that all this material is accompanied by codified knowledge. There is also a need for tools to communicate specific individual oncology patients’ cases to the colleagues of the physicists (and the physicians). Information and knowledge about cases include Cancer Type, Sex of the patient, Age, Short Description and its Author, treatment decisions over the time, treatment plans, etc. An indicative example of such a tool is the EPatCare® software tool which allows to View or Create Patient Cases. Patient cases are selected from clinical experiences and the physicians can create, edit and view “patients’ history, examination and investigation to diagnosis and treatment of the patients”. (EPatCare)
Figure 1 illustrates the role of Information and Knowledge Management for IT applications, in a Hospital Environment, and also presents a conceptual framework for applications based on I&KM and Health Information Systems. Knowledge Management (KM) systems (see Figure 1) emerged the last decades and eventually transformed to core business function for competitive organizations. Among else, major components of a successfully deployed I&KM system consist of: 1) the organizational memory module which relies on information retrieval, content based retrieval, image retrieval and 2) tools for tacit knowledge utilization such as tools for Case Based reasoning, Data mining and visualization tools. In our case of special interest are Content-Based Image Retrieval (CBIR) systems, that are CBR systems containing an image collection. In these systems retrieval can be performed using features based on pixels, which form the image’s content. It is apparent that in medical research there is an interest in combining both textual and visual features for effective image retrieval.

3. Methodology for Data and Information Collection and knowledge codification

Dalkir suggests that ‘In KM, this knowledge creation or capture may be done by individuals who work for the organization or a group within that organization, by all members of a community of practice (CoP), or by
dedicated CoP individual.’ (Semi-)Structured interviewing of experts is the most often used technique ‘to render key tacit knowledge of an individual into more explicit forms’ (Dalkir, 2011). We agree that such a semi-structured interview must have a loose structure consisting of open-ended questions that define an area to be explored (Britten, 1995). Peer group surveys should be conducted incorporating questions related to the main nine directions (job duties of the medical physicists) specified in section 2 to derive empirical data specifically from medical physicists, trainees, technicians, and doctors. It is worth of mentioning that interviews must focus on the collaboration of medical physicists with radiation oncology physicians to specify the overall plans for the radiation treatments for patients. Argote et al. believe that Knowledge transfer in organizations occurs through a variety of mechanisms and they highlighted several factors affecting knowledge sharing. Such mechanisms include personnel movement, training, communication, observation, technology transfer, “reverse engineering” products, replicating routines, patents, scientific publications and presentations, interactions with suppliers and customers, and alliances and other forms of inter-organizational relationships (Argote, 2000a), (Argote, 2000b). Armoogum and Buchgeister used five factors within CoPs to evaluate the opportunity for knowledge sharing to trainees in medical physics departments: how the spatial/departmental factors can influence the opportunity for knowledge sharing; the importance of social relationships to the sharing of knowledge; the motivation to share knowledge; channels for knowledge sharing and support for new members of the CoP (Armoogum and Buchgeister, 2010). There are several documents and other material that form a basis for an effective self-explanatory information sharing. Such material include: Publications related to new treatments or improvement of treatments already used, Dose calculation examples, Quality assurance documents of the radiotherapy equipments, health and safety legislation, Periodic reports of secure operation, written safety rules, teaching and training material, etc. The use of software tools for dose calculation, Treatment planning, and the Processing of complex patient image data are of primary interest for the collaboration of medical physicists with radiation oncology physicians in order to specify the overall plans for the radiation treatments for patients. Therefore, such material has to be selected and related knowledge must be captured and codified. Semi-structured interviews, ‘story- telling’ and other knowledge management techniques must periodically focus on specific cases of interest. Such an approach also offers the appropriate educational material for teaching and training.

Medical Images are collected from various equipments like CT, MRI, PET, SIM, TPS, Portal imaging. Any presentation and use of images of this type for sharing knowledge is restricted and anonymity has to be preserved erasing any data that can make known the identity of the patient. So for privacy reasons (to ensure anonymity), in this paper we have deleted from all the images the name of the patient, the hospital name and the date and time the image was taken from the medical device. The images we collect are organized on different areas of patient anatomy like bladder, bone (for bone metastasis), head and neck, breast, larynx, lung, melanoma, prostate, nasopharynx, tongue. Some examples of images from a simulator and its category are given in Figure 2.

4. Evaluation of the framework based on Treatment planning and knowledge codification

In this section we focus on a representative example of knowledge captured concerning a case and the related treatment plan. For simplicity reasons, the explanations -codified knowledge- are given as plain text.

A case of a patient with larynx tumour is presented (see Figure 3). The patient is treated in two phases:

- Phase I includes primary tumour and the involved cervical nodes.
- Phase II encompass the primary tumour.

The steps followed, before the radiotherapy treatment, are the following:
The head and neck region has to be immobilized with a custom-made shell to ensure reproducible patient set-up. The patient is immobilized in the supine position with the cervical spine straight.

The patient is transferred to the CT. Marking of lasers for reproducibility of positioning.

Transfer of CT images to the Treatment Planning System (TPS)

Contouring of Planning Treatment Volume (PTV) for each phase from the physician and of the critical organs or organs at risk (OAR).

Determination of the reference point (origin)

Instructions from the physician concerning the dose to the PTV and the dose limits to the OAR.

Make the plans of irradiation

In the case presented the spinal cord (SC) is an organ at risk. The dose maximum to SC at the Phase I did not exceed 4500 cgy. At Phase II the SC is not included to the PTV but it lies very close to the target volume making irradiation of tumour with SC tolerance difficult. The patient presents a special problem since he has a short neck and a high shoulder position. To overcome this use a wedged pair of anterior oblique fields and rotate the couch in order to avoid the beam passing through the shoulders while keeping SC outside the field of radiation (see Figure 3).

Sum the plans at the TPS and present the dose distribution from both phases using the DVH (Dose Volume Histogram).

Present the data to the physician who approves the plan.

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Fig. 2. (a) Breast (b) Bone (Bone metastasis) (c) Head and Neck (d) Bladder.
• Send the plans to the simulator (simulates treatment)
• Compare digitally reconstructed images (DRRs) from simulator and TPS.
• Physician’s approval
• Send the plan to the radiotherapy treatment equipment (machine)
• Check correct positioning
• Treat with the scheme instructed from the physician and the medical physicist.

If we want to publish online some cases to share information and knowledge within the framework of a radiotherapy CoP then medical physicists and radiation oncology physicians involved in the radiation treatments for patients are required to write and discuss such texts before the cases can be published online.

Fig. 3. TPS plan for treatment of larynx – Phase II

5. Conclusions and future activities

In this paper a framework for Sharing Knowledge and Integrated Information in Radiotherapy (SKIIR) is described and discussed. The proposed SKIIR is designed for medical physicists involved in Therapeutic Radiological Physics. We build on it to show how sharing knowledge can be based on specific cases of treating patients with cancer. This framework can also be used to operate an integrated system for storing knowledge and medical information related to the specific cases of interest, in any useful form and format, for the medical physicists. Various patient cases’ descriptions and related documents of primary interest for the medical physicists have to be treated, stored and organized for future use in a multimedia library including short descriptions, radiotherapy planning, ultrasound, CT and MRI images, statistical information, bibliography, discharge letters, etc. Codification of knowledge and preservation of anonymity is also discussed.

In the future our research will focus on the direction of establishing CoPs. More precisely we shall focus on the influence of the CoP in the collaboration of medical physicists with radiation oncology physicians to specify the overall plans for the radiation treatments of patients. Armoogum and Buchgeister conducted a literature review based on papers published in English between 1990 and 2008 and extracted from five (5) databases (Pubmed,
BioMed Central, Scirus and Ojose) to specifically define the radiotherapy physics team as a CoP. (Armoogum and Buchgeister, 2010). A working definition of a CoP is the following: ‘Groups of people who share a common purpose and who interact with the intent to share knowledge’. (Armoogum and Buchgeister, 2010). Armoogum, Ackland, and Gardner believe that a multidisciplinary team is essential for the successful implementation of any new treatment and especially for introducing new radiotherapy techniques into the management of patients with cancer. (Armoogum et al., 2006). Gorry suggests that strong leadership is the main prerequisite for the effective operation of the radiotherapy CoP, and time should be allowed for interaction within the CoP in order to ensure the continuing professional development. Wenger believe that ‘there are COPs developing internal barriers to knowledge sharing such as hoarding of knowledge, clique formation, limitation of innovation and exclusiveness with regard to membership.’ Bridge et al. highlights that 80% of practice in radiotherapy could be managed by non-medical practitioners who have the necessary knowledge and skills, and are based entirely within the radiotherapy centre. The authors also suggest that ‘a combination of advanced systems such as the Virtual Environment for Radiotherapy Training (VERT) and the promotion of the radiotherapy physics team as a COP is the way forward’.

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