nuclear science
and technology

Safety and Efficacy for New Techniques
and Imaging Using New Equipment
to Support European Legislation
(SENTINEL)

Contract N° FI6R-CT-2005-012909

Final report

Project co-funded by the European Commission under the Euratom Research and Training Programme on Nuclear Energy within the Sixth Framework Programme (2002-2006)
Area: Radiation protection

Directorate-General for Research
Euratom

2007 EUR 23105
### Project coordinator

Dr Keith Faulkner, QARC (UK)

### Project partners

<table>
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<tr>
<th>No</th>
<th>Organisation name</th>
<th>Country</th>
<th>Contact</th>
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<tbody>
<tr>
<td>1</td>
<td>QARC, Newcastle</td>
<td>UK</td>
<td>Dr Keith Faulkner</td>
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<tr>
<td>2</td>
<td>Haughton Institute, Dublin</td>
<td>IE</td>
<td>Prof. Jim Malone</td>
</tr>
<tr>
<td>3</td>
<td>Krankenhaus der Barmherzigen Bruder, Trier</td>
<td>DE</td>
<td>Prof. Dr H.P Busch</td>
</tr>
<tr>
<td>4</td>
<td>Azienda Ospedaliera S. Maria Della Misericordia</td>
<td>IT</td>
<td>Dr Renato Padovani</td>
</tr>
<tr>
<td>5</td>
<td>Complutense University, Madrid</td>
<td>ES</td>
<td>Prof. Eliseo Vano</td>
</tr>
<tr>
<td>6</td>
<td>Katholieke Universiteit, Leuven</td>
<td>BE</td>
<td>Prof. Hilde Bosmans</td>
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<tr>
<td>7</td>
<td>Innsbruk Medical University, Department of Radiology</td>
<td>AT</td>
<td>Prof. Werner Jaschke</td>
</tr>
<tr>
<td>8</td>
<td>Radiation Protection Department, Ministry of Health, Luxembourg</td>
<td>LU</td>
<td>Dr Carlo Back</td>
</tr>
<tr>
<td>9</td>
<td>STUK – Radiation and Nuclear Safety Authority</td>
<td>FI</td>
<td>Dr Antti Kosunen</td>
</tr>
<tr>
<td>10</td>
<td>Delft University of Technology, Netherlands</td>
<td>NL</td>
<td>Dr Joannes Zoetelief</td>
</tr>
<tr>
<td>11</td>
<td>National and Kapodistrian University of Athens</td>
<td>EL</td>
<td>Dr Sophia Kottou</td>
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<tr>
<td>12</td>
<td>Nofer Institute of Occupational Medicine, Radiation Protection Department, Lodz</td>
<td>PL</td>
<td>Prof. Jerzy Jankowski</td>
</tr>
<tr>
<td>13</td>
<td>Biomedical Research Foundation, Nicosia</td>
<td>CY</td>
<td>Dr Stelios Christofides</td>
</tr>
<tr>
<td>14</td>
<td>Ing Dusan Salat – Medicontrol, Vrbove</td>
<td>SK</td>
<td>Mr Dusan Salat</td>
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<tr>
<td>15</td>
<td>Tartu Uelikool</td>
<td>EE</td>
<td>Mr Kalle Kepler</td>
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<td>16</td>
<td>Institute of Occupational Safety, Slovenia</td>
<td>SI</td>
<td>Mr Urban Zdesar</td>
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<td>17</td>
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<td>TR</td>
<td>Prof. Mehmet Dogan Bor</td>
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<td>18</td>
<td>Physics Department, University of Pisa</td>
<td>IT</td>
<td>Prof. Alberto Del Guerra</td>
</tr>
<tr>
<td>19</td>
<td>National Centre of Radiobiology and Radiation Protection, Sofia</td>
<td>BG</td>
<td>Dr Jenia Vassileva</td>
</tr>
<tr>
<td>20</td>
<td>National Research Institute for Radiobiology and Radiohygiene, Budapest</td>
<td>HU</td>
<td>Dr Sandor Pellet</td>
</tr>
<tr>
<td>21</td>
<td>NHS Lanarkshire Health Board, Scotland</td>
<td>UK</td>
<td>Dr Robert H Corbett</td>
</tr>
<tr>
<td>22</td>
<td>Institute of Public Health, Bucharest</td>
<td>RO</td>
<td>Dr Constantin Milu</td>
</tr>
</tbody>
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Project execution

Introduction

The past two decades witnessed a technologically-driven revolution in radiology. At the centre of these developments has been the use of computing in diagnostic imaging. These developments have also been driven by the introduction of new detectors and imaging devices in radiology and nuclear medicine as well as the widespread application of computing techniques to enhance and extract information within the images acquired. Further advances have been introduced into clinical practice. However these technological developments have not been matched by justification and optimisation studies to ensure that these new imaging devices and techniques are as effective as might be or performed at the lowest possible dose.

This project has dealt with radiation protection, safety, and related issues that arise from the above developments in radiology. It covered over 90% of patient examinations, 60% of the collective dose from medical sources, and approximately 50% of the collective dose from man-made sources. In practice this project dealt with almost all radiological digital imaging outside of CT scanning.

Objectives

The intention of the coordinated action, which spanned

- functional and objective equipment performance and international standards
- dosimetry, constancy testing and QA
- justification, ethics, and efficacy
- guidelines, good practice, and training materials,

was to underwrite the safety, efficacy and ethical aspects of clinical practice, whilst protecting and adding value to the products and of the associated knowledge-based equipment, devices, IT, and services industries.

A series of studies were undertaken on the justification and optimisation of new and emerging imaging techniques. These studies commented on examinations or were associated with high individual doses, frequently performed, or apply to more sensitive groups. The main objectives of this coordination action were to:

1. Establish both physical and clinical image quality criteria, and link the two
2. Perform a series of dosimetry studies
3. Develop good practice guidelines for radiation protection, and training material.
Development of the project in respect of work package achievements

Equipment surveys on digital imaging systems occur as part of acceptance-testing and quality-control programmes. The goal of work package 1 was to refine and develop these and to inform standards development.

Optimisation of any imaging system is predicated by an understanding of the relationship between physical and clinical image-quality indices. The objective of work package 2 was to address the optimisation issue in the context of new digital imaging systems. Refinement of acceptance and constancy testing will contribute to standardisation activities.

High-dose procedures were considered in work packages 3 and 4. The goal of these work packages was to undertake surveys of functional performance and doses for patients and to assess the results to develop reference doses according to the complexity of the procedure. Contribution to the standardisation of the DICOM header was another objective.

Population screening and sensitive groups are covered in work package 5 (digital mammography, bone mineral densitometry and paediatric radiology). The optimisation of these imaging processes was a goal.

Work package 6 dealt with justification, ethics and efficacy in relation to radiation protection. The goal of this work package was to engage in discussions with the general public as a whole and a broad spectrum of religious leaders to establish rounded views on ethical issues associated with radiation protection.

The objective of work package 7 was to develop training courses and teaching material on various aspects of radiation protection. Work package 8 dealt with the project management.

Each work package was split into two or three deliverables. In order to achieve these deliverables on time, they were subdivided into a series of tasks. Many of these tasks related to the undertaking of surveys of radiation dose, image quality and current practice in relation to interventional radiology, cardiology, training and ethical issues. All survey questionnaires were agreed with partners and circulated. Replies have been discussed and supplementary information sought where relevant. For example, a common approach to patient dosimetry in cardiology and interventional radiology was agreed. In addition, an approach to take into account the complexity of cardiology procedures when comparing centres has been refined. In the justification, ethics and efficacy work package, a number of ethical issues have been identified and prioritised. Surveys of European practice have been completed in these priority areas.
Dissemination of knowledge commenced via a series of courses, training meetings and seminars. These activities were supplemented via the World Wide Web using an existing website (www.dimond3.org) and the SENTINEL site (www.sentinel.eu.com). A conference and publication in collaboration with EURADOS occurred.

Some aspects of the project involve the development of software. This was tested in centres associated with the SENTINEL partners. It is intended to commercially exploit this work given that the initial assessment was favourable.

The SENTINEL coordination action has worked closely with the International Electrotechnical Commission (IEC), especially in interventional radiology, mammography and the use of the DICOM header for quality assurance and radiation protection. Accurate online patient dosimetry will be facilitated upon the agreement of the contents of the DICOM header. Meetings with IEC were held to improve the development of quality standards, so that a consensus on acceptance testing and quality assurance could be achieved. This activity was supplemented by a review of test procedures and tool kits amongst the consortium partners.

The review of equipment performance for new detectors in digital projection radiography was completed. Software to assist in the constancy testing of digital radiography equipment in clinical practice was designed, developed and subjected to rigorous testing. A consensus on optimisation criteria for digital projection radiography was achieved and presented at one of the SENTINEL training workshops.

In interventional cardiology and interventional radiology the SENTINEL team has been very active and agreed on the performance assessment of new flat panel detectors for cardiology, the design and contents of a patient dosimetry database, image quality criteria and on optimisation strategies. These activities were supplemented by patient and staff dose surveys from which reference levels were deduced. For interventional radiology, similar activities occurred and common protocols for the assessment of patient and staff dosimetry were written. A consensus on optimisation approaches in interventional radiology and the use of the DICOM header information has been achieved.

Efficacy and safety in population screening and sensitive groups was addressed. This involved the development of common approaches to paediatric dosimetry. A literature review of patient dose surveys and reference levels was undertaken. Justification issues in breast screening, bowel cancer screening and bone mineral densitometry have been successfully completed.

With respect to justification, ethics and efficacy, a number of studies were undertaken. Areas of ethical concern associated with the introduction of new technology in radiology were studied. This has included consent/authorisation, the inadvertent irradiation of the foetus/embryo during pregnancy and the place of paternalism/individual autonomy in radiation protection practice. Studies were completed which have considered the ethical issues associated with screening. The ethics of medico-legal and self-referral examinations were also considered.
Implications

The outputs from this coordination action have impacted both upon the research community and regulatory bodies. For example, the dose-survey data have been incorporated in the Medical Exposures section of the forthcoming UNSCEAR report. Information obtained as part of this coordination action has informed the decisions of Committee 3 of the ICRP and the Article 32 Group of the Euratom Treaty. Intervventional standards on radiology equipment and the DICOM header have also drawn upon the work undertaken in the SENTINEL coordination action.

The major achievements of the SENTINEL coordination action were:

1. Development of a consensus between end users and industry regarding standardisation of radiology equipment. (Milestone WP 1)
2. Agreement on image quality assessment approaches in interventional radiology. (Milestone WP 1)
3. Development of an equipment performance assessment and measurement protocols for new imaging devices. (Deliverable WP 1)
4. Proposal of an international standard for the use of the DICOM header for dosimetry and QA information. (Deliverable WP 1)
5. A review of the imaging performance of direct digital, dental and nuclear medicine equipment. (Deliverable WP 2)
6. Production of a consensus document on dose and image quality optimisation of digital radiography systems based upon the EC’s referral criteria. (Deliverable WP 2/Milestone WP 2)
7. Consensus conference on quality and dose management. (Milestone WP 2)
8. Proposals for the performance assessment of digital fluoroscopy equipment use for interventional radiology and cardiology. (Deliverable WP 3, Milestone WP 3/Milestone WP 4)
9. Establishment of reference levels in cardiology. (Milestone WP 3)
10. Proposals for reference levels for common interventional radiology and cardiology procedures arising from consensus meeting (taking into account complexity of procedures). (Deliverable WP 3/Milestone WP 3)
11. Proposals for optimisation of interventional radiology. (Deliverable WP 4)
12. Patient and staff dose surveys in interventional radiology and cardiology and guidelines for their reduction. (Deliverable WP 4/Milestone WP 4)
13. Consensus meeting on performing national dose surveys. (Milestone WP 4)
14. Special requirements for paediatric equipment proposal. (Milestone WP 5)
15. Referral criteria development and refinement. (Milestone WP 5)

16. Proposals for the establishment of reference doses in paediatric radiology. (Deliverable WP 5)

17. Completion of feasibility study on the use of the DICOM header for dose retrieval in mammography. (Milestone WP 5)

18. Development of quality assurance procedures for bone mineral densitometry systems. (Deliverable WP 5)

19. Testing of an automated approach to reading and processing of image quality phantoms. (Deliverable WP 5)

20. Development of MoniQA, a software tool for assessing display workstation performance. (Deliverable WP 5)

21. Review of ethical permission and consent issues in radiation protection. (Milestone WP 6)

22. Assessment of ethics and consent in radiation protection research. (Deliverable WP 6)

23. Discussion document on ethical issues in screening procedures. (Deliverable WP 6)

24. Identification of ethical issues in pregnancy and fertility procedures. (Milestone WP 6)

25. Identification of ethical issues in medico-legal procedures and budget-limited procedures. (Milestone WP 6)

26. Development of good-practice guidance. (Deliverable WP 7, Milestone WP 7)

27. Delivery of a number of training courses. (Deliverable WP 7, Milestone WP 7)

**Dissemination and use**

The results of the coordination action have been disseminated in a number of ways. In addition to the normal academic channels of scientific publication and presentations at conferences/seminars (see Annex 4), a website has been created, www.sentinel.eu.com. In addition, there have been significant and high-profile efforts to engage the public with these research findings. This has taken the form of patient information leaflets and a presentation at the European Science Forum. Of particular note was the Dublin ethics meeting at which ethics and radiation protection were discussed with members of the public, members of the European Parliament and various forms of the media.

Training material in the form of PowerPoint presentations may be downloaded from the website. In addition, training syllabi and associated documentation have been
produced. These may also be obtained from the coordination action website (www.dimond3.org).

Training material on digital radiography, interventional cardiology/interventional radiology, patient dosimetry and quality control, digital mammography, and radiation protection in medicine are available.

The training course on ethics and radiation protection has proven to be particularly successful. It is intended to publish this training material as a special issue of *Radiation Protection Dosimetry*.

**Exploitable knowledge and its use**

As part of this co-ordination action various software tools for the automated analysis of images, the performance of quality assurance tests and the quality control of workstations and monitors were developed. These software tools have the potential for industrial and commercial exploitation in the future, but are at present in a prototype stage. These software tools will be brought to the workplace once tried and tested in radiology departments within the consortium.

Intellectual property rights, patents and ownership will be discussed at an appropriate stage. It is likely that these software tools will require further development if they are to be commercially exploited.

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It is likely that Optimage will become open-access software. This would ensure its wider availability. The exploitation of MoniQA is to be reviewed as there are individual intellectual property rights issues to be considered.
### Dissemination of knowledge

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## Training meetings

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<td>Venice, Italy</td>
<td>Cardiology</td>
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<td>Lodz, Poland</td>
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<td><strong>2006</strong></td>
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<td>Trier, Germany</td>
<td>Expert Training Course</td>
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<td>Digital Projection Radiography</td>
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<td>Leuven, Belgium</td>
<td>Mammography/Digital Radiography</td>
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<td>Madrid, Spain</td>
<td>Radiation Protection in Interventional Radiology</td>
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<td>Paris, France</td>
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<td>Budapest, Hungary</td>
<td>Radiation Protection for Interventional Cardiologists and Radiologists</td>
<td>5-6 July 2006</td>
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<tr>
<td>Pisa, Italy</td>
<td>Training of Medical Physicists for Diagnostic Radiology (study GP collaboration EFOMP-SENTINEL)</td>
<td>6-7 Sept 2006</td>
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<td>Dublin, Ireland</td>
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<td>Helsinki, Finland</td>
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<td>Venice, Italy</td>
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<td>Leuven, Belgium</td>
<td>Workshop for SENTINEL partners on image quality in digital mammography, part radiological evaluation</td>
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<td>Newcastle, UK</td>
<td>Digital Mammography &amp; the Breast Screening Programme</td>
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<td>Nicosia, Cyprus</td>
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<td>Nicosia, Cyprus</td>
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<td>15 Feb 2007</td>
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<tr>
<td>Delft, the Netherlands</td>
<td>SENTINEL Workshop</td>
<td>18-20 April 2007</td>
</tr>
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</table>
Acknowledgements

The SENTINEL partners wish to thank all the organisations and individuals with whom they have collaborated for their input into the project.
Annex A: Published papers

PARTNER 1, QARC


8. E Vano, K Faulkner, CG Orton. A major advantage of digital imaging for general radiography is the potential for reduced patient dose so film/screen systems should be phased out as unnecessarily hazardous. Medical Physics 2006, 33 (6), 1529-1531.


PARTNER 2, HI/SJH


PARTNER 3, BK Trier

1. K. Faulkner, H.P. Busch, S. Schopphoven, Assessment of patient Organ Dose in CT Virtual Colonoscopy for Bowel Cancer Screening, Radiation Protection Dosimetry (in press)

PARTNER 4 AOSMM


14. R.Padovani et al., Reference levels at European level for cardiac interventional procedures, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007 (to be published in Rad. Prot and Dosim.)

15. R.Padovani et al., Patient skin doses in interventional radiology and cardiology; practice in 6 countries participating in an IAEA coordinated research project, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007 (to be published in Rad. Prot and Dosim.)


18. C.Foti, R. Padovani et al, Staff dosimetry in interventional cardiology: survey on methods and level of exposure, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007 (to be published in Rad. Prot and Dosim.)


20. W.E.Muhogora, R. Padovani et al., Application of European protocol in the evaluation of contrast noise ratio and mean glandular dose for two digital mammography systems, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007 (to be published in Rad. Prot and Dosim.)

21. F.Bonutti, Count-rate analysis from clinical scans in PET with LSO detectors, SENTINEL Workshop, Delft, the Netherlands, April 18-20, 2007 (to be published in Rad. Prot. and Dosim.)

Development of training material


3. R. Padovani: Training module: Maximum skin dose evaluation with large area detectors, IAEA, Radiation Protection in Diagnostic and Interventional Radiology, November 2005


PARTNER 5, UCM


PARTNER 6, K.U. Leuven

International peer-reviewed papers


mammography systems (results of the first acceptance tests on digital mammography systems), Radiation Protection Dosimetry (in press)


PARTNER 8, CRP Santé

1. Changing from image intensifier to flat detector technology-practical experience from the national interventional cardiology centre in Luxemburg, Radiation Protection Dosimetry (in press)

2. Review of existing issues and practices in general medical research and radiation protection research, Radiation Protection Dosimetry (in press)

3. Review of existing issues and practices with respect to irradiation of patients and staff during pregnancy, Radiation Protection Dosimetry (in press)

PARTNER 11, NKUA/SARG

PARTNER 12, NIOM


PARTNER 14, Ing Dusan Salat – Medicontrol


PARTNER 15, UT


PARTNER 16, IOS

PARTNER 17, AUFE


PARTNER 19, NCRRP


15. Vassileva J. Quality Assurance in Diagnostic Radiology – European requirements. XII Congress of Bulgarian Association of Radiology, Sunny Beach, 19-22 October 2006, Abstract in Rentgenology Radiology Suppl. 06


18. Dimov A. J. Vassileva. Patient doses during chest radiography and fluoroscopy. XII Congress of Bulgarian Association of Radiology, Sunny Beach, 19-22 October 2006, Abstract in Rentgenology Radiology Suppl. 06

PARTNER 20, NCPH-NRIRRE


4. F. Giczi: Patient Protection in Diagnostic Radiology – Hungarian Participation in the SENTINEL Project, Radiation Protection Training Course organized by the Semmelweis Medical University, Budapest, 23 February 2006 (conference proceedings)


PARTNER 22, IPH
**Annex B: Conference presentations**

PARTNER 1, QARC


27. R. Padovani, K. Faulkner: The SENTINEL project (invited lecture), First Central & Eastern European Workshop on Quality Control, Patient Dosimetry and Radiation Protection in Diagnostic and Interventional Radiology and Nuclear Medicine, Budapest (Hungary), 25-27 April 2007

PARTNER 2, HI / SJH


8. Various lectures at the DEXA Radiation Protection Seminar, Wednesday 25th and Thursday 26th October 2006, Trinity Centre for Health Sciences, St. James’s Hospital, Dublin, Ireland.

9. Various lectures at the SENTINEL Training Course on Ethical Issues in Radiation Protection For Diagnostic Imaging, 15th February 2007, Holiday Inn, Nicosia, Cyprus


11. Lecture on workshop ‘Radiation Protection in Medicine, Past, Present and Future Challenges’, Nofer institute of occupational medicine, Lodz, Poland, 26th October 2005.


PARTNER 3, BK Trier

4. S. Schopphoven: Legal rules and standards for QA of Digital Radiography in Germany (Sentinel-Meeting February 2006, Trier, Germany)
5. S. Schopphoven: Dose-watching – patient dose DR (Sentinel-Meeting February 2006, Trier, Germany)

PARTNER 4, AOSMM

3. R. Padovani, S. De Crescenzo, R. Ropolo, P. Cortivo Indagine nazionale per l’aggiornamento dei LDR per la radiodiagnostica del paziente adulto - gruppo di lavoro AIFM–SIRM, IV AIFM Congress, Verona (Italy), 14-17 Jun 2005

4. R. Padovani, Analisi dei rischi da radiazioni ionizzanti connessi con l’attività di radiodiagnostica e radiologia interventistica, Medical Physics Advanced School Caldirola, Gazzada (Varese, Italy), May 2005

5. R. Padovani, Dose, qualita’ di immagine e LDR in radiologia digitale statica e dinamica, Forum Mediterraneo di Fisica Medica: Lo stato dell’arte e le prospettive future delle apparecchiature di diagnostica per immagini, Lampedusa (Agrigento, Italy), 27-30 Sept 2005,


7. R. Padovani, Valutazione fisica della qualità d’immagine, Corso Itinerante di mammografia digitale: dalla teoria alla pratica, Udine (Italy), Jan 2006

8. R. Padovani, Basic principles of flat panel detectors, SENTINEL: Training Course Digital Projection Radiography, Trier (Germany), 16 Feb 2006


11. R. Padovani, Patient dosimetry in IR and dosimetry and image quality in 3D acquisition Image evaluation in 3D reconstruction, International meeting on: Advances in Patient Dosimetry and Quality Control in Interventional Radiology: The SENTINEL European Programme San Carlo University Hospital, Madrid (Spain), 21-22, April 2006


14. R. Padovani, E. Vano, S. Pellet, K. Faulkner, SENTINEL - Training course on radiation protection for interventional cardiologists and radiologist, Budapest (Hungary), 5-6 July 2006


20. R. Padovani, F. Bonutti, Patient exposure with hybrid systems, SENTINEL Workshop on Dose and Optimisation Approaches for Nuclear Medicine: Hybrid Systems, Nicosia (Cyprus), 14 Feb 2007


27. G. Bernardi, R. Padovani et al, A trial on an updated set of quality criteria for
cardiac images, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007

28. R. Padovani et al., Reference levels at European level for cardiac interventional procedures, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007

29. R. Padovani et al., Patient skin doses in interventional radiology and cardiology; practice in 6 countries participating in an IAEA coordinated research project, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007


32. C. Foti, R. Padovani et al, Staff dosimetry in interventional cardiology: survey on methods and level of exposure, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007


34. W. E. Muhogora, R. Padovani et al., Application of European protocol in the evaluation of contrast noise ratio and mean glandular dose for two digital mammography systems, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007

35. F. Bonutti, Count-rate analysis from clinical scans in PET with LSO detectors, SENTINEL Workshop, Delft, The Netherlands, April 18-20, 2007


37. Padovani R, Bonutti F., Patient dosimetry for hybrid imaging systems: PET/CT and SPECT/CT, 2nd International Saudi Symposium on Medical Physics, Riyadh (Saudi Arabia) 7-9 May 2007

38. R. Padovani, Integrazione HIS/RIS/PACS, reti locali (LAN) e di area vasta (WAN), Corso di aggiornamento SIRM: La teleradiologia, Udine (Italy), 11 May 2007

PARTNER 5, UCM
   b) (B-770) A six year follow up of patient dose values: Transition from


d) Invited presentation on Radiation Safety in Interventional Radiology.


a) European multi-media course for training on radiation protection for interventional radiology: Some results after three years of experience. Guibelalde, E. Vano, E. González, L.

b) Spanish requirements in radiological protection training for the practice of interventional radiology. A five years experience. Eliseo Vano, Francisco Vargas, Mercedes Bezares, Luciano González, Antoni Segarra.


b) Practical experience with the use of dynamic flat detectors. Invited speaker: E. Vano. Control/Tracking Number: 06-I-965-ECR.


a) Invited presentation E. Vano): “Strategies to reduce doses in the IR suite”.


b) Optimisation of dose and image quality in digital pediatric voiding Cystourethrography. E. Vano-Galvan, R. Sanchez Jacob, E. Vano, J. Fernandez Soto; Madrid/ES.


d) Using DICOM header to improve interventional radiology practice: An European consensus initiative. E. Vano1, K. Faulkner2, R. Padovani3, S. Kottou4, H. Jarvinen5, H. Bosmans6, A. Schreiner7, C. Maccia8, J.
Vassileva9, J.M. Fernandez1, J.I. Ten1, J.M. Ordiales1; 1Madrid/ES, 2Newcastle/UK, 3Udine/IT, 4Athens/GR, 5Helsinki/FI, 6Leuven/BE, 7Luxembourg/LU, 8Bourg La Reine/FR, 9Sofia/BG.


h) Criteria to optimize a dynamic a flat detector system used for interventional radiology. R Simon, E Vano, C Prieto, JM Fernandez, J.M. Ordiales, D.
PARTNER 10, TUC-IRI
2. F.W. Schultz, Effective dose and dose conversion coefficients in paediatric radiology. SENTINEL WP5 Helsinki meeting November, 2006

PARTNER 11, NKUA-SARG
1. ATHENIAN DAYS OF INTERVENTIONAL RADIOLOGY 2005:
a) How much can the radiation dose differ from patient to patient in lower limb diagnostic angiography and which could be the reasons? V. Tsapaki, E. Mavrikou, E. Papageorgiou, S. Kottou, A. Orfanos, G. Karidas, T. Fidani, E. Zafiriadou, V. Neofotistou
b) Correlation of patient and staff doses in Interventional Cardiology V. Tsapaki, S. Kottou, E. Vano, T. Parviainen, R. Padovani, A. Dowling, M. Moffetas, V. Neofotistou
2. ESCR 2006:
a) "A methodology to optimize Interventional Cardiology procedures as part of the SENTINEL project", V. Tsapaki, poster 72.
b) "Level of patient and operator dose in a large Cardiac Centre in Greece", V. Tsapaki, poster 155.

c) "Entrance surface doses (ESD) during chest X-ray (CXR) computed radiography (CR) in a cardiology paediatric intensive care unit (ICU)", N. Kollaros, poster 156.

3. ITAB 2006:


4. QANTRM 2006:
   a) "Comparison of radiation doses in permanent cardiac pacemaker implantation in three Greek hospitals", E. Papageorgiou, IAEA-CN-146/258P.

5. DELFT 2007 (presentations / posters):

b) Patient skin dose assessment during CT guided interventional procedures. V Tsapaki, C Triantopoulou, P Maniatis, S Kottou, J Tsalafoutas, J Papailiou

c) High patient doses as a result of physician’s negligence. How it can be prevented? S. Kottou, I. Mavrikou, V. Tsapaki, E. Neofotistou

d) Acceptance and constancy tests for digital angiographic units. V Tsapaki, R Padovani, E Vano, A Schreiner, V Neofotistou, S Kottou

PARTNER 12, NIOM


3. Doses received by patients and staff during cardiac procedures, J. Jankowski, S. Papierz, J. Domienik, A. Werduch, J. Kacprzyk. For Brasov conference (24-28 September 2007)
PARTNER 13, BRF


PARTNER 17, AUFE


3. D. Bor, E Onal, T. Olğar, A. Caglan, T. Toklu Estimation of Cardiologist Radiation Doses received during the interventional examinations. American


PARTNER 18, UNIPIISA


PARTNER 21, NHSLHB

1. R. Corbett, Ethics and Justification in Radiation Protection, Hairmyres Hospital, 16 March 2007
2. R. Corbett, Ethics and Justification in Radiation Protection, 2nd European Radiation Congress, 24-28 September 2007

PARTNER 22, IPH

5. C. Milu, 14 training courses on “Radiation protection in diagnostic radiology and in interventional radiology”, organized by the Institute of Public Health, in 2006 and 2007 (520 radiologists, from the whole country).
Annex C: Software

OPTIMAGE – CENTRAL ORGANISED IMAGE QUALITY CONTROL INCLUDING STATISTICS AND REPORTING

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\textsuperscript{2} Brüderkrankenhaus Trier (DE)  
\textsuperscript{3} Ministry of Health, Division of Radiation Protection, Luxembourg (LU)

Quality control of medical imaging systems – traditionally performed using phantom images, which are evaluated by human observers – is becoming more and more difficult and time consuming. Therefore, the evaluation of phantom images with adequate image processing software might help to save evaluation time and to receive more objective results.

The developed software package OPTIMAGE has a central approach for the evaluation of digital phantom images: On the one hand OPTIMAGE provides a framework, which includes special functions like automatic update, database integration and connectivity, DICOM data sources, image processing functionality and statistical components for reporting. On the other hand the test methods are implemented using modules. All of these modules are handled in the same way, which simplifies the use of the software. Tests are currently available for the following modules: CR and DR systems, radiography and mammography, CT, nuclear medicine and MRI.

Every test is based on a test profile. This profile contains information about the used phantom, the acquisition parameters and the specific tested modality. Performing measurements with the software requires only a few working steps: After the selection of the images, the profile has to be selected. Then the verification process checks if the phantom was positioned correctly and if the images were taken according to the correct technical parameters. An automatic analysis of the phantom images takes place. Final results are shown, including a conclusion concerning whether the tested modality can be used or not in clinical practice. Results can be assessed and evaluated in a dedicated statistics area: visualisation options as well as an export of the data are available. The reporting functionality helps to report the performance of a result over time.

The first feedbacks from users in Luxembourg and Germany show a great acceptance of the software, but it needs more tests in daily routine conditions in order to obtain more information about reference values. The available statistical functions and the reporting allow a fast and efficient overview of the acquired data.

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In a digital radiology department, medical images are no longer being visualised on film and viewing boxes (hardcopy) but on high-end display devices (softcopy viewing). To maintain the highest quality of diagnostic reading, a careful daily quality-control procedure of these display devices should be carried out. This is especially true in breast cancer screening programmes. Several protocols (AAPMtg18, DIN 6868-57, EUREF) to assure this quality exist but they all suffer from their static nature and their implementation limitations in current clinical practice. During the past years, we developed a new approach to simplify the task of daily quality control of display devices and to increase the reliability of the evaluation results. This newly developed procedure (MoniQA) consists of a software framework written in Java and variable physical test patterns.

In this paper, we will report on the first results of a multi-centre study which we have performed throughout the past year. We will discuss the various quality control routines used in the different centres and we will also describe the developed software infrastructure to automate the process of quality control. Several other novel methods to check for the influence of external factors diminishing the apparent image quality (ambient light levels, viewing angle issues) will be discussed.

We believe that the described solutions will simplify the process of quality control and by that increase or consolidate the trust radiologists have in their clinical findings.

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