Ionizing Radiation in the Italian Health Care, Radiological Protection Aspects and Research

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Outlook

- Italian Healthcare
- Ionizing Radiation in Medicine
- Snapshots on few research lines
Italian Healthcare System (simplified)

Ministry of Health
(Regulation, Programming, Control, Surveillance, Funding)

Regional Authorities
(Control, Surveillance, Distribution of Funding, Support to Central Authority)

- CSN (National Scientific Commission)
- AIFA (Drug)
- AGeNaS (Quality of Service)
- INAIL (Occupational Health)
- ISS (Public Health)
- IZS’s (Food)

Public Hospitals

Private Hospitals

ASL’s (Local Healthcare Agency)

Other Ministries

Universities

General Hospitals

- ENEA
- INFN, CNR
- ISPRA

IRCCS (Research Hospitals)

Scientific Societies, Professional Associations
The first Italian particle accelerator. Designed by the «via Panisperna boys». Began operation in 1939 at ISS.

Applications: medical (e.g. radiopharmaceutical production) and nuclear physics research.

The Italian Institute of Health (Istituto Superiore di Sanità) was established in 1937.

Mission: Promotion and protection of public health through research, surveillance, regulation, communication, counselling and training.

Promotion and protection of national and international public health.
Patient Centred Healthcare

The value **this patient** places on benefits and harms of the options

The clinical condition of **this patient**: diagnoses, risk factors, genetic profile, psychological, social issues

Best current evidence derived from the study of groups of patients

Personalised and Precision Medicine

Choice

Decision

Adequate reporting

Freely adapted from Sir Muir Gray / Healthcare Value, ISS 2018
Ionizing Radiations in Medicine

Radiations in Medicine

Diagnostic Radiology
- Radiography, fluoroscopy
- Mammography
- Computer Tomography

Nuclear Medicine
- Diagnostic Imaging (SPECT, PET)
- Radiometabolic therapy (MRT)

External Radiotherapy
- Conventional radiotherapy
- Hadrontherapy
- Brachytherapy

Preclinical Research

Min. Health/2013 Clinic Branches
<table>
<thead>
<tr>
<th>Health Services</th>
<th>Million</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging - Radiology</td>
<td>58.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Imaging – Nuclear Medicine</td>
<td>2.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Radiotherapy</td>
<td>4.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Lab. Analyses (Phys. Chem. Biolog.)</td>
<td>1016.2</td>
<td>78.8</td>
</tr>
<tr>
<td>All Other branches</td>
<td>207.4</td>
<td>16.1</td>
</tr>
</tbody>
</table>

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Bonn Call for Actions in Rad. Prot. In Medicine

1. Enhance the implementation of the **principle of justification**
2. Enhance the implementation of the **principle of optimization** of protection and safety
3. Strengthen **manufacturers’** role in contributing to the overall **safety regime**
4. Strengthen radiation protection **education and training** of health professionals
5. Shape and promote a **strategic research agenda** for radiation protection in medicine
6. Increase availability of improved **global information on medical exposures** and occupational exposures in medicine
7. Improve **prevention of** medical radiation **incidents and accidents**
8. Strengthen **radiation safety culture** in health care
9. Foster an **improved radiation benefit-risk-dialogue**
10. Strengthen the **implementation of safety** requirements globally

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Justification & (Rad.) Medical Imaging

Radiological Medical applications expanded over time

Increased issues on justification / appropriateness

Medical Exposure of Patients (2006)
- Computed Tomography: 49%
- Nuclear Medicine: 26%
- Interventional fluoroscopy: 14%
- Conventional Radiography/fluoroscopy: 11%

Italy:

~58 M rad. medical imaging exams/years (in 2013, Ministry of Health)

Last 7 years: +30% radiological exams, +100% CT

Analog to digital radiology

A strongly «multi-variable» problem

Innovations add Pro’s but may introduce Con’s that need careful analysis

From: http://www.upstate.edu/radiology/education/rsna/radiography/issues.php

Italy (2015/Assobiomedica): ~50% of radiological devices in operation are analog
MRT is expanding thanks to new radiopharmaceuticals, imaging devices, personalized theranostic ...


“Results from studies [in MRT] involving dosimetry are encouraging and inspiring, but further robust and collaborative studies are clearly necessary”


“Dosimetry-based individualisation of treatment [in MRT] is likely to significantly improve this effectiveness, although must be adequately resourced”
Radiation related projects in Health research

Only «Ricerca Finalizzata» considered!

Health Finalized Research (2016) & Radiation

Total eligible applications on each sector: 568, 702, 108
Clinical outcomes depend on how well we know and control the physics and biological processes involved in diagnosis and/or therapy and how make them happen.
Linear Accelerator for Therapy

👍 Compact and lightweight

👍 Radiation «clean»

👍 Power efficient

👍 Very Modular: customizable according to needs; operational during its construction

👍 Performances: all physics properties (energy, intensity, direction, ...) of the particle beam can be varied quickly and actively offering **improved precision** and **larger flexibility on dose delivery** to the patient (e.g. optimal intrafraction motion control)

👎 Only single ion type can be accelerated

👎 Never used before in therapy (but physical modality similar to photon therapy)
LinAc for Therapy becoming real

TOP-IMPLART facility

Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Istituto Nazionale Tumori Regina Elena
Istituto di Ricerca e Cura a Carattere Scientifico

Italian National Institute of Health

Regione Lazio

Status:
Current Energy: 35 MeV
Current/Pulse: 30 uA
(135 MeV in about 2 years)

Already in operation for:
• Beam and diagnostics characterization
• Radiobiology studies
• Cultural heritage analyses
• New development (e.g. LiF dosimetry)
• Radioprotection optimization studies

Current projects on LinAc for PT:
LIGHT, Erha, TOP-IMPLART

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This process gives contribution also outside the tumor region and change the proton RBE. About 10% of biological effect in the entrance channel due to secondary fragments (Grun 2013).

Largest contributions of recoil fragments expected from He, C, Be, O, N. In particular on Normal Tissue Complication Probability.

See also:
- Paganetti 2002 PMB
- Grassberger 2011 PMB
Radiobiology in different exposure scenarios

- Dose (rate) relationship for cancer and non-cancer risk
- Possible existence of dose (rate) threshold(s) for different biological systems/end points
- Role of radiation quality in triggering biological responses

LNGS-INFN (underground lab)
ISS / LNGS-INFN (external labs)
ISS – LIBIS Low dose rate $\gamma$-irradiator (external lab)

Low Radiation Environment (LRE)
Reference Radiation Environment(s) (RRE)
Increased gamma Radiation Environment(s) (IRE)

Cs-137 sources:
- $18.5 \text{ GBq}$
- $740 \text{ MBq}$
- $37 \text{ MBq}$

Adapted from A. Tabocchini
Radioguided Surgery, a new PARADIGM

- Use of $\beta^-$ tracers (electrons): pros
  - Detect electrons that travel $\sim100$ times less than gamma
  - Tracers with $^{90}$Y can be used (already used for Molecular RT)
  - No background from gamma
    - Shorter time to have a response
    - Smaller administered activity
    - Smaller and more versatile detector
    - Very reduced effect of nearby healthy tissues
    - Reduced dose to medical staff

Adapted from R. Faccini  
**INFN-UNiRoma**

Radionuclides for Nuclear Medicine

SPES Project

- 70 MeV cyclotron
- Study of neutron-rich nuclei for astrophysics
- Production of high-intensity neutron sources
- Production of radionuclides for medicine

LARAMED
Laboratory for the production of exotic RADionuclides for MEDicine

Evaluation of a New Sorgentina Fusion Source (NSFS) to produce an intense (about $10^{15}$ n/s) 14 MeV neutron beam by D-T reaction for conventional (99mTc) and short-lived radioactive isotopes (e.g. $^{64}$Cu for theranostic) production.

Mo-99

Personal final remarks

• Healthcare is a very complex system which is (or going to be) centred on patient

• Ionizing Radiation has a relevant role in healthcare and there is (large) margin of improvements (direction is well summarized by BCfA’s)

• Perception of radiation risk in general public is typically «overexpressed» respect to other risks

• Ionizing Radiation related research in (Italian) healthcare is probably «underexpressed», due also to lack of a “robust collaboration framework” between potential multidisciplinary actors

Apologize for the very limited and partial view on the presented ongoing research
Quality assurance

QA of:

– Equipments
– Procedures
– Clinical Protocols
– Organization
– Education/Training

Maximize the patient benefit (diagnostic and therapeutical) minimizing errors and adverse events

Experts from Scientific Societies, Professional Associations (AIMN, AIFM, TSRM, AIRP, SIRM, ...) and Institutional Bodies (IRCSS, INAIL, ISS, AGeNaS, ...) produce QA guidelines in radiological science

Patient Radiological Protection and Quality Assurance in Radiological Science