Emergency Response to Radiological Accidents and International Medical Assistance in Peru

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General Aspects

• The use of radiation sources steadily increasing in the last decade and so radiological risks. Enhanced radiation protection measures are needed for preventing the radiation accidents and incidents.

• Four radiation accidents with consequences to public and workers occurred in 20 years.

• Radiological accident came from radiotherapy practices and industrial radiography. Accidents resulted in higher localized doses in one member of the public and three workers.
General Aspects

- Peruvian Institute for Nuclear Energy (IPEN) is the regulatory body for controlling ionizing radiation sources in the country through authorizations, inspections and enforcement as well as issuing rules and regulations.
- Regulatory body coordinates emergency preparation and response.
- A National Radiological Emergency Plan (NREP) in place for radiological response to accidental situations.
- NREP includes the categorization of emergencies, organization and responsibilities, operational procedures and arrangements for intervention, emergency preparation and international coordination for support through Conventions of Notification and Assistance.
National Situation

• Nearly 5600 organizations using almost 9500 ionizing radiation sources in the country (most of them are medical X-ray machines)
• There are almost 3500 radioactive sources but only 5% of them are sealed radioactive sources of IAEA Category 1 and 2
• There are also one critical facility of zero power and one research reactor of 10 Mw as well as a radioisotope production plant and one facility for management of radioactive waste
Control System in Place

• Radioactive and nuclear facilities controlled by a system of authorization, inspection and enforcement according to approved rules and regulations

• Authorization process requires applicant to demonstrate that all necessary arrangements for the safety and protection, including an emergency plan, are in place.

• Radioactive sources of most concern: cobalt units and lineal accelerators in medicine, gamma irradiators for research and industrial irradiation, iridium 192 sources in industrial radiography and americium 241/beryllium neutron sources
Emergency Response

• Regulations require licensees having an emergency plan for responding to radiation accidents.

• At first no consideration was given to cases where emergencies could affect people and environment beyond the facility boundaries or cases where international assistance was needed.

• Attention arrangements for radiation emergencies was implemented two decades ago and the first directive for attending radiation emergencies was approved.

• The emergency plan has been revised and updated in 2009 being entitled as National Radiological Emergency Plan with scope just for radiological response.
Features of Emergency Plan

- Emergency Plan comprises the planning basis, the response process and the declaration of emergency termination and also provisions for emergency preparation, the international coordination, the interinstitutional relationship and the updating process.

- Provisions for operational concept and procedures for each category of emergency.

- Response performed through an organization composed by teams for planning, radiation monitoring and sampling, source recovery and radioactive waste, radiological evaluation and advice, internal contamination evaluation and biological dosimetry, radionuclide identification, public communication, resources and supplies, amongst others.
Organization for Response to Emergencies

- **Planning**
  - Interventional planning
  - Recovery planning

- **Operational Teams**
  - Radiological monitoring and sampling
  - Sources recovery and radioactive waste
  - Radiological evaluation and advising
  - Internal contamination and biological dosimetry
  - Radionuclide identification

- **Management and supplies**
  - Transport
  - Food and material supplies
  - Communication

- **Public Information**

- **Head of Radiological Emergencies**
Notificacion and Intervention

• Notifications of accidents received by a Telephone Centre which is run by security guards of IPEN.

• Transmission of notification to team of first responders. Response team activated after confirmation of notification.

• Other organizations involved in an emergency, but not under an Integrated Plan for Radiation Emergencies (currently under development for being approved by the National Institute for Civil Defence.)
Main Radiation Accidents

• Four radiation accidents with health consequences in last 20 years.
• Accidents in radiotherapy and industrial radiography.
• Two members of public and two workers were affected.
• Other minor incidents occurred without any consequence.
Arequipa accident

- Date and place: November 16th, 1995 in a Hospital in Arequipa city
- Electrician attempted to repair a cobalt unit head and touched the $^{60}$Co source having 79.4 TBq, receiving a dose over 25 Gy in their fingers of right hand and almost 0.9 Gy to whole body.
- Accident not notified to Regulatory Body and discovered 20 days after overexposure happened.
- National Institute for Cancer provided treatment to electrician.
- Localized doses on the fingers were too high and becoming amputated after a few weeks.
- Response to emergency focused on medical attention.
- Regulatory body intervened for assuring the control of radioactive source and for investigating the causes of accident.
- Hospital temporarily closed by regulatory body and specific measures for preventing were adopted and applied to all of radiotherapy facilities.
Yanango accident

- Date and place: February 21\textsuperscript{th}, 1999 in Yanango, San Ramon, Junin.
- A $^{192}$Ir source having 1,4 TBq became inadvertently detached from camera and fell on the floor. A welder found the source and put it on his back pocket remaining there by nearly 6 hours. At the end of the working day the welder went at home where he lived with his wife and son but after a short time he took the source out of its home. The source remained in that place until the owner arrived at midnight and recovered it.
- Welder received a high localized dose (more than 100 Gy) on his left leg and lower doses (ranging from 1 to 1,5 Gy) at other parts of his body. His wife also received radiation doses which caused ulcerative lesions that healed after six months.
- First medical attention provided by the National Institute for Cancer. Doses calculation were deemed non-confident.
- IPEN requested to IAEA a Mission for Medical Advice and Dosimetry after two weeks.
Yanango accident

- IAEA Mission recommended following of monitoring and condition of patient.
- After three months the patient’s health worsened and he was taken to Hospital Percy in France for specialized medical treatment.
- Funds for treatment of patient were supported by several organizations besides IAEA as USA Government and IRPA and others.
- Assistance and cooperation also provided by REAC/TS for biological dosimetry.
- Despite the treatment in the Hospital Percy, the patient’s right leg was amputated (hemi-pelvectomy) and, after five months, he returned to Peru. The treatment continued since then through the governmental social security in Arequipa city.
- The company of industrial radiography was definitively closed by regulatory body and the radiography equipment was seized.
- The patient continued living in Arequipa and its injuries were under treatment for a long time.
Chilca

• Date and place: January 12\textsuperscript{th}, 2012 in the location of Chilca in Lima.

• Three workers performing several radiographies on pipes with a $^{192}\text{Ir}$ source having 3,69 TBq. Possibly after the first radiography was taken the source became detached and remained in the top of tube guide. The workers were not aware of this fact and moved and set the guide tube for making other several exposures. Just at the end of the journey they became aware that the source had been in the guide tube all the time and then proceeding to recovery the source and put it inside the camera.

• Workers had shown symptoms during the radiography operations and they were taken to a small medical center for a basic attention and then to a private medical center.

• Radiography company notified the accident to regulatory body which requested to take the workers at the Cancer Institute for urgent clinic examination and treatment.
Chilca

• Emergency response activated and estimation of doses and coordination for medical attention to workers were initiated.
• IPEN requested the assistance to IAEA in the frame of Convention for Assistance and an action plan was implemented.
• It was estimated that first worker received almost 50 Gy in a finger of left hand and about 4.6 Gy to whole body. The doses to other two workers were estimated in 1 Gy to whole body. As the dose to worker’s finger had been too high it was amputated and, currently, any recidivism has happened and appearing to have a good healing.
• The regulatory body performed investigations of the accident and sanctioned the company by suspending temporarily its licence.
Callao

• Date and place: February 14th, 2014, chemical plant located in Ventanilla, Callao.
• Three workers performing radiographies on pipes in the plant were overexposed to abnormal doses. Radiographies were being taken in a noisy zone of the plant what prevented worker to hear the alarm dosimeters. Portable radiation monitor was not used as well as any visual warning about the radiation levels.
• Workers were aware of the event when they were moving away the noisy area and began to hear the alarm dosimeters. They monitored the guide tube realizing that the unshielded source was there.
• The workers recovered the source and put inside the camera and notified to company manager.
• Workers were sent to a medical centre for first medical attention and blood analysis.
• Company notified the accident to regulatory body which began response and investigation.
Callao

• Regulatory body inspected the place for assuring that radioactive sources were in safe condition and then for reconstruction of event and estimation of doses.

• Medical attention of patient was provided by National Institute for Cancer and international assistance was shortly requested to IAEA.

• As a result the most exposed worker received up to 25 Gy on his left hip causing localized injuries and 110 mSv to whole body doses.

• Other two workers received no more than 17 mSv to whole body. The patient has well recovered and showing no recidivism until now.

• Regulatory body suspended the licences to company and two operators.
Need for international support

• It cannot be overlooked that some capabilities do not exist or are not well developed and consequently international support had to be considered.

• Except the radiological accident in Arequipa, all of other events required the specialized assistance from IAEA and other international organizations.

• Assistance involved dosimetry estimation, biological dosimetry, medical advice and treatment of patient.

• It was necessary to establish the scope and extent of the assistance through an action plan.
Experience on international assistance (First accident)

- Uncertainty in the urgency of the health care caused from a distrusted dose estimate
- Many offers of helping and support came to IPEN and some choices had to be done
- Consequence: Some delay in the request for assistance on medical advice and treatment of patient, and also for patient dosimetry (Requested two weeks after accident although some informal communication provided before speeded up the assistance)
- Strategy for monitoring and treatment of the patient jointly agreed between national and IAEA expert physicians.
- Assistance and support from international organizations proven very valuable.
Experience on international assistance  
(Two other events)

- Assistance was requested more easily as procedure was known in advance allowing to set the scope and time of such assistance.
- Medical advice and treatment were timely and appropriately provided in both cases.
- These facts favoured a quick and adequate treatment of patients and helping to their health recovery.
- The novelties were the use of existing medical facilities and capabilities for treatment in the Latin-American region (Brazil and Chile) as well as the use of the LABNet network for cytogenetic dosimetry.
Improving effectiveness of internacional assistance

• Experience cases attests the importance of having implemented an emergency plan for response to accidents.

• Emergency plans should include arrangements for international assistance in order to deal with aspects where the country's capacity is limited or non-existent.
Effectiveness of assistance

Appropriateness and effectiveness of international assistance depends on:

- Identifying the type and scope of support needed for addressing international efforts on what really matters
- Promptness of the request and assistance when accidental overexposures to high doses has happened allowing to implement an appropriate strategy and more effective medical treatment
- Availability of complementary funds which must be foreseen in advance, as treatment of patient is usually expensive, otherwise the treatment could be delayed and radiation injures worsened.
- Taking advantage of the regional laboratories for biological analysis as Latin-American Network for Biological Dosimetry (LBDNet) and also of specialized medical facilities for treatment
- Appointment of technical coordinators to facilitate implementing of action plan.
Conclusions

• It is very important having in place an emergency plan for an appropriate and timely response to radiation accidents, including arrangements for international assistance, in special when medical attention to injured people or urgent mitigation actions or countermeasures are involved.

• It is important also to keep in mind that prevention of accidents should be a paramount goal. It is better to keep in place all protection and safety systems and being always aware of the radiological risk for applying measures that anticipate abnormal situations.
Thank you

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