A Short Summary of Accidents Involving Radiation

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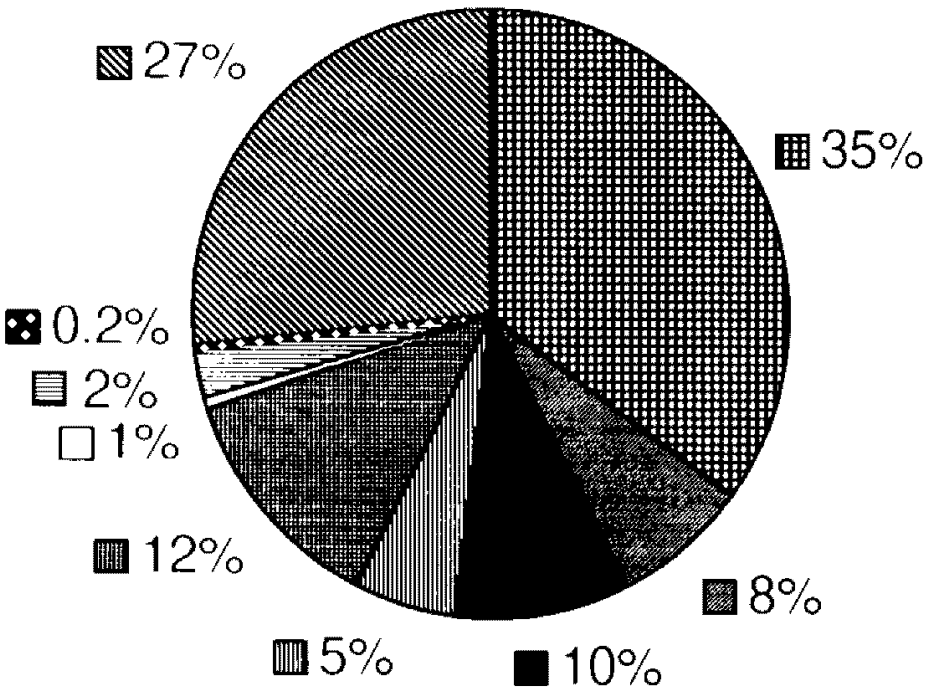
Types of Accidents Involving Radiation

- Accidents in nuclear reactors
- Accidents in research nuclear reactors
- Accidents in miliyary nuclear reactors
- Criticality accidents
- Accelerator accidents
- Dispersion of radioactive material
- Internal exposure to radioisotopes
- Accidents with an irradiator
- Medical accidents in radiotherapy
- Medical accidents in radiodiagnostic
- Orphan sources
- Dispersion of orphan sources

Types of Accidents Involving Radiation



- Industry
- Irradiator
- Laboratory
- Reactor
- Medical
- Military
- Educational
- Waste
- Unknown / other

Accident Statistics 1886 - 2009

- **391 documented events in total**
- **135 (35%) related to medical or industrial radiography, radiotherapy, lost sources, theft, suicide or homicide, isotope ingestión or dispersion**
- **45 countries**
- **32 cases (8.2%) in radiotherapy**
- **181 deaths**
- **1176 injured**

Accident Statistics 1886 - 2009

RUSSIA	193
USA	51
CHINA	21
ENGLAND	12
WEST GERMANY	11
ARGENTINA	11
EAST GERMANY	10
FRANCE	9
INDIA	9
JAPAN	5
CHECKSLOVAKIA	4

Accidents Involving Medical and Industrial Applications

Medical and industrial Radiography	49
Radiotherapy	32
Lost sources	23
Suicide, Homicide, criminal intent	19
Theft	8
Dispersion	2
Isotope Ingestion	2
Radiotherapy Accidents in the USA	17
Deaths	22
Physical damage	100

Accidents in the United States

- **52 accidents of all types**
- **14% of all the accidents in the world**
- **17 accidents in radiotherapy (33%)**
- **22 deaths**
- **100 injured**

Classification of Accidents

- **Of inmediate identification**
  - **Easily manageable and of limited number of victims (H igh or medium dose rate medical or industrial**
  - **Difficult management (Brasil, Mexican border, Perú)**
  - **Catastrophic (Chernobyl,**
- **Of delayed identification**
  - **Mexico DF (stolen cobalt source), Italy (irradiator) Argelia, Morocco (HDR Ir) El Salvador (Irradiator) Cairo (found industrial source), France and Vietnam (wrong repair or use of linear accelerator)**
- **Criminal action**
  - **Sources used as weapons (El Salvador, USA, Francia, Londres)**
- **Accidents kept secret**

Types of Accidents

- Minor
- Major
- Catastrophic

Types of Accidents

- One or a few victims
- Many people in a limited area
- Many people over a large area

Terminology for Medical Errors

- **Incidents**
- **Events**
- **Errors**
- **Misadministrations**
- **Unusual ocurrences**
- **Discrepancies**
- **Adverse Events**

Definitions from the World Health Organization

Incident: An event or circumstance that could have resulted or resulted as unnnecessary damage to a patient

Error: The failure to complete a planned action according to its intended purpose or the implementation of an incorrect plan through the execution of an incorrect action (error of commission) or the failure to execute the correct action either during the planning phase or during its execution (error of omision)

Avoidance of Treatment Errors

Error

"The failure of planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (i.e., error of planning)."

Institute of Medicine. To Err is Human: Building a Safer Health System, 2000.

- Note: Random and systematic "errors" should be called "uncertainties"

Accidents in Radiotherapy

Generally speaking, treatment of a disease with radiotherapy represents a twofold risk for the patient**:**

- **Firstly, and primarily, there is the** potential failure to control **the initial disease, which, when it is malignant, is eventually lethal to the patient;**
- **Secondly, there is the** risk to normal tissue **from increased exposure to radiation.**

Thus in radiotherapy an accident or a misadministration is significant **if it results** in either an underdose or an overdose**, whereas in conventional radiation protection only overdoses are generally of concern.**

IAEA: Categories of Errors

Categories	*Number of errors*
Radiation measurement systems	5
External beam:	
Machine commissioning & calibration	15
External beam therapy:	
Treatment planning, patient setup and treatment	26
Decommissioning of teletherapy equipment	2
Mechanical and electrical malfunctions	4
Brachytherapy:	
Low dose rate sources and applicators	29
Brachytherapy: High dose rate	3
Unsealed sources	8
	92

Medical Errors - General

US annual errors

- 44K-98K people die from medical errors
- More than motor vehicle accidents, breast cancer or AIDS
- Total annual cost $37.6 to $50 billion

Most common types

- Technical (44%)
- Diagnosis (17%)
- Failure to prevent injury (12%)
- Use of drugs (10%)

Institute of Medicine. To Err is Human: Building a Safer Health System, 2000.

"Keep the Patients Safe"

"**Human error per se does not usually kill patients, but human error in a weak system can injure or even kill. A weak safety culture, weak operational practices, weaknesses in the presence of protocols and training, weaknesses in communication and serious weaknesses in the packaging and design of drugs. In short,** comprehensive systems weaknesses greatly increase the risk of harm coming to a patient**."**

Sir Liam Donaldson, Chief Medical Officer, England, March 2003
http://www.iqa.org/publication/c4-1-78.shtml

Errors in RT: Contributing Factors

- Insufficient education
- Lack of procedures/protocols as part of comprehensive QA program
- Lack of supervision of compliance with QA program
- Lack of training for “unusual” situations
- Lack of a “safety culture”

Sources of Uncertainties During Treatment

- **Machine performance**
- **Determination of dose from radiation**
- **Patient specific data for treatment planning**
- **Calculation of radiation dose to the patient**
- **Transfer of data from the treatment plan to the treatment machine**
- **Day to day variations in the treatment (machine/patient motion/set up)**

Accidert vs Incident

Accident: any non planned during which it is very possible that the established dose limits may have been exceeded

Incident: any non planned event during which it is very possible that the nolmal dosis may have been exceeded

In both cases the administered dose does not agree with that planned.

In many cases accidents cause injuries or death

Classification of Incidents

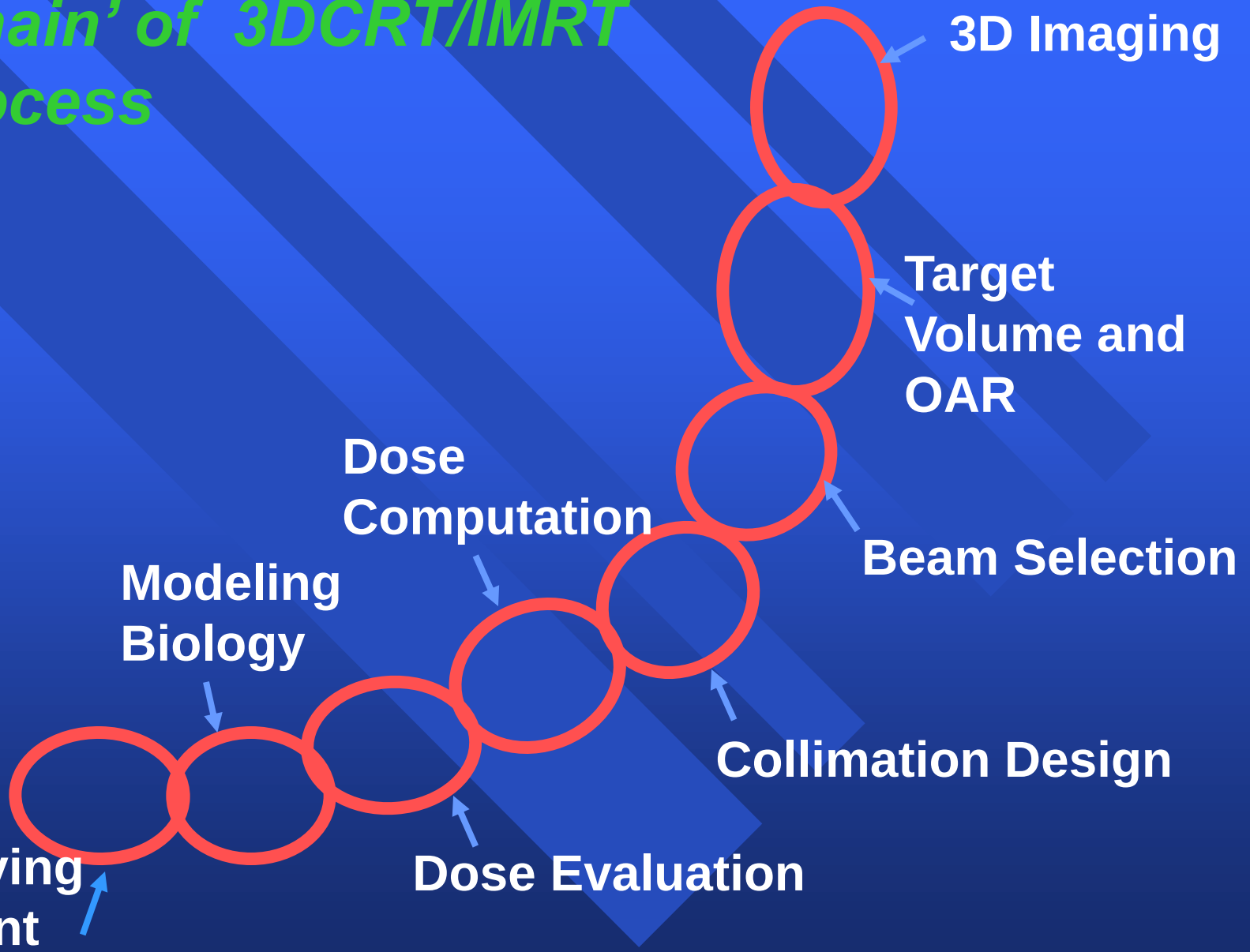
Recordable: any incident that deviates from the desired doses must be investigated and reported internally

Reportable: any incident that is over the in agreement with established criteria

Incidents per Stage of the Treatment

- Decision to treat and prescription
- Positioning and inmobilization
- Simulation, imaging and volume delineation
- Comissioning
- Treatment planning
- Transfer of information
- Patient positioning
- Treatment delivery

'Chain' of 3DCRT/IMRT Process



Steve Webb, 1992

Incidents During Evaluation

- **Incorrect Identificationof the patient**
- **Incorrect patient record**
- **Wrong diagnosis (staging, spread, …)**
- **Inadequate records**

Incidents During the Decision to Treat

- **Lack of coordination with the other specialties**
- **Lack of identification of the physician in charge**
- **Failure to transfer the patient to the correct pysician and at the right ime**
- **Wrong diagnosis, inadequate protocol**
- **Lack of multidisciplinary discussion**

Incidents During the Decision to Treat

- Incorrect identification of the patient
- Lack of coordination with other modalities
- Missing components of the prescription
- Inapropriate authorization of the incomplete prescription
- Alterations of the prescription

Incidents During Inmobilization

- **The patient is unable to comply with the inmobilization requirements**
- **Incorrect positioning**
- **Different positioning for different imaging modalities**
- **Incorrect inmobilizatin position**
- **Wrong inmobilization device**
- **Wrong transfer of the inmobilization instructions**

Incidents During Imaging or Simulation (1)

- Incorrect identification of the patient
- Wrong localization of reference points
- Wrong volumen definition
- Incorrect tumor margins
- Incorrect contouring of the organs at risk
- Lack of alignment of the light fields or the cross hairs
- Inability to identify the isocenter

Incidents During Imaging or Simulation (2)

- Incorrect identification of the patient
- Wrong localization of reference points
- Wrong volumen definition
- Incorrect tumor margins
- Incorrect contouring of the organs at risk
- Lack of alignment of the light fields or the cross hairs
- Inability to identify the isocenter

Incidents During Planning

- **Wrong calibration**
- **Incorrect dosimetry data**
- **Incorrect data (decay, constant tables)**
- **Inadequate use of the software,wrong monitor unit calculation**
- **Lack of independent verification**
- **Incorrect plan (modality, energy, field size, normalización, prescription point, use of bolus, %DD, etc)**

Incidents During the Transfer of Information (1)

- **Incorrect identificación of the patient**
- **Manual data entry**
- **Design of an incompatible chart**
- **Unreadable handwriting for manual transfers**
- **No independent verification**
- **Incorrect data entry in the record and verify system**
- **Ambiguous or badly written prescripción**

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Incidents During the Transfer of Information (2)

- **Proceed with a plan without approval**
- **Failure to communicate plan changes**
- **Error in the monitor units, accessories, wedges**

Incidents Positioning the Patient

- **Incorrect patient identification**
- **Failure to evaluate the medical condition of the patient**
- **Wrong positioning, wrong inmobilization device, wrong side of the body, wrong isocenter**
- **Treatment unnecessarily complex**
- **The patient was moving during treatment**

Incidents Delivering Treatment (1)

- **Undetected equipment failure**
- **Equipment operated in physics mode instead of clinic mode**
- **Incorrect identification of the patient**
- **Poor management of the patient**
- **Incorrect field or orientation**

Incidents Delivering Treatment (2)

- **Excessive or not enough fractions**
- **Inadequate verification of the treatment parameters**
- **Warm up procedures not followed**

Incidents at Record and Verify

- Incorrect identification of the patient
- Incorrect use or lack of portal images
- Wrong interpretation of the portal images
- Failure to monitor results
- Lack of patient evaluation
- Absent or deficient record review
- Undetected errors

Factors Contributing to Errors in Radiotherapy

- Insuficient education
- Lack of protocols/procedures as part of a QA program
- Lack of supervision to follow the QA program
- Lack of training on unusual situations
- Abscense of a “safety culture”

The Important Laws of Medical Physics

Inverse square

Decay

Brag-Gray

Probabilities

Murphy

Anything that can go wrong will go wrong

If something cannot go wrong, it will go wrong anyway

Murphy

If everything seems to be going well

you do not know what is going on

Murphy?

Things to Have in Mind

- **Accidents happen**
- **They happen even in the best of circumstances**
- **They happen to the “best of the best”**

The Bottom Line…

… is not whether an accident will happen but rather

- **How soon it is discovered**
- **How it is corrected**
- **How it is prevented from happening again**

Establish a culture of prevention

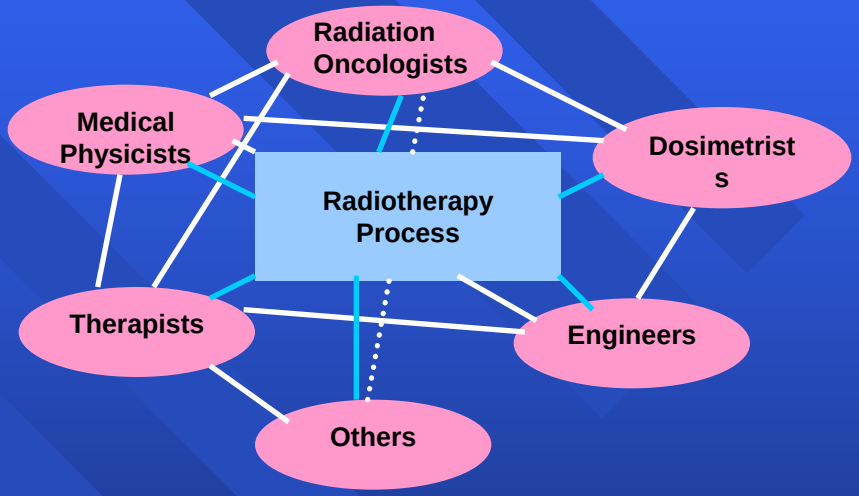
Who is Responsible

- Radiation oncologists
- Medical physicists
- Radiotherapy technologists (therapists)
- Radiation protectionofficers (local and national)
- Hospital Director, Service Chief, Administrator

The Multidisciplinary Team

Radiotherapy is a multidisciplinary process.

Responsibilities are shared between the different disciplines and must be clearly defined.



- Each group has an important part in the output of the entire process, and their overall roles, as well as their specific quality assurance roles, are interdependent, requiring close cooperation..

The Worrying Signs

- **Our staff is the best trained and experienced, we do not make mistakes**
- **If there were problems with these units the manufacturer would not sell them**
- **There is no reason to worry, we have worked like this for 20 years with no problems**

The Worrying Signs

- We have our own techniques and do not care about what others say
- We paid $3 million dollars for this equipmen, how can it make mistakes
- We have everything computerized, and therefore error free
- I have been in this field for many years, I do not make mistakes
- It is not allowed for medical physicists or radiotherapy technologists to challenge or question a physician plan

Thank You