Radiotherapy - Oncology

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Use of RT in Oncologic Care

- To provide definitive treatment where radiation is the sole curative local modality.
- To allow organ preservation following an organ sparing surgical resection.
- To increase the likelihood of local/regional control following a radical surgical extirpation.
- To provide palliation of symptoms from primary or metastatic tumor growth.

Optimization of Radiotherapy

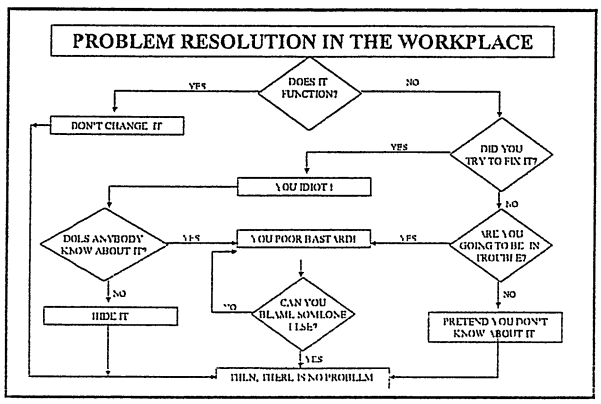
Ways:

- ✓ Treatment combinations.
- ✓ Radiosensitizesrs.
- ✓ Radioprotective substances.
- ✓ Obtimisation of radiotherapy (planing, treatments, e.c.t.r.).

Optimization of Radiotherapy

New techinques.

- Προσαρμοσμένη Ακτινοθεραπεία.
  Conformal Radiotherapy.
- Αντίστροφος Σχεδιασμός Θεραπείας.
  Inverse Treatment Planning.
- Ακτινοθεραπεία με Διαμόρφωση της Έντασης της Δέσμης.
  Intensity Modulated Radiation Therapy (IMRT).

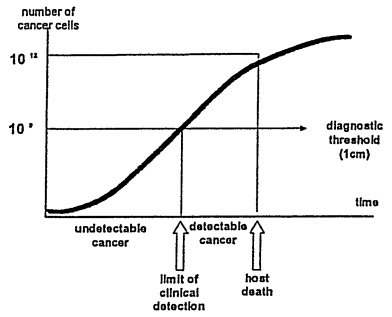


Conclusions

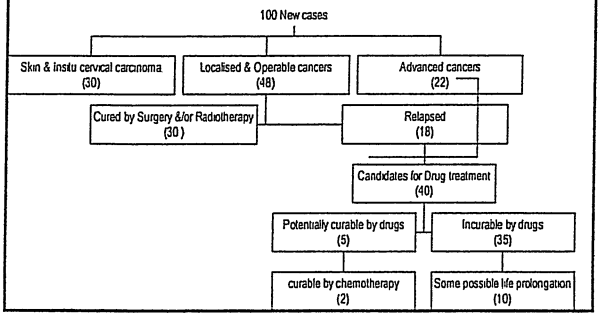
- ✓ Radiation therapy for local control!
- ✓ Multimodality treatment is the ideal treatment for cancer (loco-regional control)
- ✓ Meetings special designed to confront the problem!

- ✓ Can we eliminate cancer?
- ✓ What is bothering us delivering bigger dose?
- ✓ What does it mean radioresistant tamour?

Tumor Growth



Relative roles of Local & Systemic Treatment



Cancer Radiation Sensitivity

Sensitive tumors	*Radiation-resistant tumors*
Seminoma	**Melanoma**
Lymphoma	**Osteosarcoma**
Neuroblastoma	**Glioblastoma**
Medulloblastoma	**Carcinomas**
Myeloma	

Radiation Therapy

Curative as sole treatment

Head & neck cancer	Early lung cancer
Cancer of the cervix	Lymphoma
Anal cancer	Seminoma
Skin cancer	Neuroblastoma
Bladder cancer	Medulloblastoma
Prostate cancer	Choroidal melanoma
	Thyroid Cancer

Cancer Radiation Sensitivity

Radiation-resistant tumors

Melanoma
Osteosarcoma
Glioblastoma
Renal Carcinoma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Errors and Accidents in Radiotherapy

What can we learn from a major radiation therapy accident, and from the literature.

Overview of the most relevant accidents in Radiotherapy

Country	Year	No of patients affected	Causes and main contributing factors
USA	1974-76	426	Co-60 dose calculations based on erroneous decay chart (varyin No independent verification of dose calculations More than two years without beam measurements
Germany	1986-87	86	Co-60 dose calculations based on erroneous dose tables (varyin No independent determination of the dose rate
UK	1988	207	Error in the calibration of a Co-60 therapy unit (25% overdose) No independent calibration of the beam
UK	1988 89	22	Error in the identification of Cs-137 brachytherapy sources dosimetry errors) No independent determination of source strength
Spain	1990	27 (several deaths)	Error in the maintenance of a clinical linear accelerator, transferring machine from and to maintenance (informing followed Conflicting signals and displays ignored Procedures for periodic beam verifications (QA) not implement
UK	1982-91	nearly 1,000	Inappropriate commissioning of a computerized Treatment Plan 30% underdosage)
USA	1992	1 (death)	Brachytherapy source (High Dose Rate) left inside the patient. Source dislodged from equipment Conflicting monitor signals and displays ignored
Costa Rica	1996	115 (several deaths)	Error in calculation during the calibration of Co-60 therapy unit Lack of independent calibration and of QA Recommendations of external audit ignored

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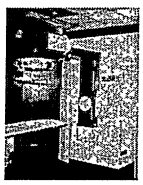
Accidental Overexposure of Radiotherapy patients in San Jose, Costa Rica.

Alkyon II



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- A cobalt-60 source was replaced on August 22nd, 1996.
- Due to a number of factors {the trigging mechanism being miscalculation of source output factors), 112 patients were given actual doses that were up to 60 % in excess of the prescribed dose.
- The equipment was closed for therapy September 27th 1996, and officially by the Government on Octobers, 1996.

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- At review by the IAEA group, July 7-11, 1997, 76 patients were alive, whereas 36 had died.
- 69 of the 76 patients that were alive interviewed and examined by the IAEA group
- Details about the 36 deceased patient were evaluated at the Department of Forensic Medicine

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- The patients were usually treated at 70 -80 cm SSD.
- Only 1 or 2 beams were used in almost all cases, AP-PA being frequently used.
- Treatment planning was done only at level 1 (ICRU), and thus no isode distributions were available.
- In most cases, only one field was treated at each
- fraction.

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- 113 patients, treated August 22 - September 27,1996
- Distribution on diagnoses.
- -18 Cervix. -14 Breast, -12 Head & Neck.
- - 9 Lymphoma.
- - 7 Endometr. + other gyn.
- - 6 CNS.
- - 5 Leukaemia +• Myeloma.
- - 5 Colo-rectal -t- Gastric.
- - 4 Medulloblastoma
- - 4 Soft tissue sarcoma.
- - 4 Embryonal ca.
- - 4 Skin.
- - 4 Oesophagus,
- - 3 Mets.UNS.
- - 3 Prostate,
- - 11 Misc.

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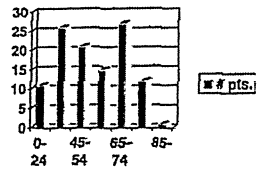
- 113 patients, treated August 22 - September 27,1996. Age distribution.



Beam miscalibration of ^{60}Co (Costa Rica, 1996)

- Radioactive source of a teletherapy unit was exchanged
- During beam calibration, reading of the timer was confused, leading to underestimation of the dose rate
- Subsequent treatment times were calculated with the wrong dose rate and were about 60% longer than required
- 115 patients were affected; two years after the event, at least 17 patients had died from the overexposure

Beam miscalibration of ^{60}Co (Costa Rica, 1996)



- Failure to perform independent calibration
- Failure to notice that treatment times were too long for a new source with higher activity

Child affected by overdoses to brain and spinal cord and lost his ability to speak and walk

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Situation October 1998.

- 53 patients being alive. Findings at clinical examination:
- 2 Severe or catastrophic effects.
- 12 Marked effects, with high risk for the future.
- 22 Radiation effects seemingly not severe,

but tome risk for the future.

- 13 No definite effects seen, little risk for the future,
- 2 Underexposed patients.
- 2 Could not be seen

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Situation October 1998: 61 deceased patients.

Findings from the review of clinical and postmortem records:

- 13 Radiation related death.
- 4 Possibly radiation related death.
- 35 Death not related to radiation.
- 9 Not enough data to Judge.

=

- 61

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- Situation October 1998
  Overall estimation of effects in 114 overexposed patients.

- 15 Clinically catastrophic /lethal effects.
- 16 Marked effects/ contributary to death
- 22 Radiation effect seen, but presently not severe.
- 48 No signs of overexposure/ death due tumour, or other causes
- 2 Underexposed.
- 11 Not evaluable.
- =
- 114

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Initiating event:
0.3 min (18s) was taken as 30 s, thus leading to an overexposure to patients.

Contributing factors:
- Insufficient understanding of radiotherapy physics.
- Lack of independent absorbed dose determination.
- Lack of QA programme.
- Lack of overall supervision.

Measures for prevention:
- Independent absorbed dose determination of the beam should be in place.
- Education credentials and training of physicists responsible for the calibration and dosimetry should be an essential step before assigning responsibilities
- A QA programme and sufficient supervision of carrying it out are indispensable for accident prevention.

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- **RECORDS ON THE PARTICIPATION**
- **OFTHE SAN JOAN DE DIOS HOSPITAL**
- **IN THE IAEA/WHO TLD POSTAJL DOSE CHECK SERVICE**
- **P. Andreo and J. Izewska**
- **Dosiroetry nod Medical Radialion Physics Section, Division of Human Health, IAEA**

Year		Beam	Deviation (*)
1990		Co-60/1:	20.5%
1991		Co-60/1:	7.1%
1992		Co-60/1:	26.3%
		Co-60/2.	25.9%
1994		Co 60/1:	68.9%
		Co-60/2:	69.8%
1995		Co-60/1:	38.3%
		Co-60/2:	25.5%
1995	("blind test")	Co-60/1:	-5.9%
	("blind test")	Co-60/2:	-7.2%

(*) relative deviation (%) = 100 x (user stated dose - IAEA measured dose) / IAEA measured dose

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6.51. SUMMARY RECOMMENDATIONS
- Recommendations to the Government of Costa Rica:
- Radiation therapy is necessary and should be continued in Costa Rica.
- Existing regulations should be implemented and enforced as soon as possible.
- Quality assurance programmes should be developed and implemented.
- Education and training for radiation therapy staff should be improved.
- Record keeping in radiotherapy charts should be improved.
- Radiotherapy in general should be improved to avoid unnecessary and unacceptable harmful outcomes.
- If external auditing discovers significant, persistent and continuing problems, another channel of communication to the authorities should be sought.
- Major medical and psychosocial support should be provided now to many patients and will probably be needed for at least the next five years.
- A registry of data on patients should be set up.

- Radiation measurement systems, N= 5
- External beam therapy; machine commissioning and calibration, N= 14
- External beam therapy: treatment planning, patient set up, and treatment, N- 27
- Decommissioning of teletherapy equipment, N= 2
- Mechanical and electrical malfunctions, N= 4
- Brachytherapy: low-dose rate sources and applicators, N- 28
- Brachytherapy: high dose rate, N= 3
- Unsealed sources, N= 8
- Category of procedure where mistakes were made in 91 evaluated accidents {Working material /ICRP/IAEA 1998: "Lessons learned from accidents in radiotherapy").

- **Design error in accelerator control software. Multiple inconsistent sets of basic machine data. Incorrect data for tissue-maximum ratios.**
- **Insufficient understanding of treatment planning system algorithm. Incorrect basic data in treatment planning system. Incorrect depth dose data. Incorrect calculation of treatment times. Misapplication of distance correction. Incorrect calculation using the inverse square law.** **cont'd**
- (1/3) Category of procedure where mistakes were made in 27 evaluated accidents in external beam radiation therapy. (Working material ICRP/IAEA 1998: "Lessons learned from accidents in radiotherapy").

- Incorrect calculation of treatment times for open and wedged beams.
- Error in wedge factor.
- Wedge factor used twice in calculation of treatment times.
- Failure to include intended wedges in the treatment set-up.
- Misunderstanding of a complex treatment plan given verbally.
- Incorrect identification of patient.
- Treatment set-up based on another patient's chart.
- Calculation error after a change of treatment regimen.
- Confusion of fractional dose and total dose.
- cont'd
- (2/3) Category of procedure where mistakes were made in 27 evaluated accidents in external beam radiation therapy. (Working material ICRP/IAEA 1998: "Lessons learned from accidents in radiotherapy").

- Incorrect positioning of treatment beams.
- Wrong tattoo used in treatment set-up.
- Miscommunication because of language problem.
- Incorrect labeling of a simulator film.
- Field improperly located on patient.
- Field improperly located on patient.
- Incorrect positioning of patient.
- Improper positioning of patient for treatment.
- Machine incorrectly set for rotation, rather than a stationary field.
- (3/3) Category of procedure where mistakes were made in 27 evaluated accidents in external beam radiation therapy. (Working material ICRP/IAEA 1998: "Lessons learned from accidents in radiotherapy1').

Some comments on the human factor in accidents in radiation therapy. (Working material ICRP/IAEA 1998: "Lessons learned from accidents in radiotherapy").

- A review of the mistakes shows that most are due to human errors, rather than failure of equipment.
- Rarely are all steps in radiotherapy performed by a single individual; in most institutions, many people work together, each contributing a small part of the entire process.

Some comments on the human factor in accidents in radiation therapy. (Working material ICRP/IAEA 1998: "Lessons learned from accidents in radiotherapy").

- The potential for mistakes is large, and that for various reasons, *e.g.;*
- lack of training,
- lack of documentation,
- lack of clear procedure,
- poor communication.

Some comments on the human factor in accidents in radiation therapy. (Working material ICRP/IAEA 1998: "Lessons learned from accidents in radiotherapy").

Even well trained and well qualified personnel make errors, due to

⇨ carelessness,

⇨ inattention to details

⇨ sometimes when having to work in less than ideal situations.

- Independent checks can help detect the above mentioned errors.
- Finding a systemic error, such as an incorrect calibration procedure, may require the service of an outside, independent person.
- The purpose of such checks is to find errors in the procedure, not to find a care-less member of the staff.

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- **Adequate training,**
- **defined responsibilities,**
- **a good radiation culture,**
- **and an open mind.**

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PSYCHOSOCIAL EFFECTS (1/3).

- Persons who are involved in an accident are often thought to have post-traumatic stress disorder (PTSD). This disorder is typically seen after "understandable" accidents, *e.g.* a fire, or an earthquake, which is large, sudden, and then over.
  Adaptation towards a goal can take place.
- Patients exposed accidentally to any radiation may have special concerns related to the unfamiliarity of radiation.

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- Experience with the population around Chernoby) has shown that the traditional PTSD effects seen and the patient manifestations are not the same.
- A term which has been proposed as a result of study of the psychological issues at Chernobyl is "chronic environmental stress disorder" owing to the continued presence of, and exposure to, environmental radioactive contamination. The patients will have to live with the knowledge that the potential effects may not be over or may not even be evident for years.

Hospital San Juan de Dios, San Jose, Costa Rica. PSYCHOSOCIAL EFFECTS (3/3).

- Psychosocial problems associated with this accident were clearly evident. These related to:
- the issue of radiation exposure without somatic effect, issues related to having been involved in an accident, issues related to the direct effects of radiation.