2022 POSTER

Radiotherapy capacity in Europe 2009: results of the EUNICE project

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Background: Within the framework of the European Commission (EC) Health Monitoring Programme, the EC awarded a grant for a project entitled EUNICE (European Network for Indicators on Cancer). The objectives of EUNICE were to establish and operate a network of data providers, to provide the EU with updated and standardized indicators on cancer burden and care.
Materials and Methods: "Europe" is defined as 33 countries: the 27 Members of the European Union, the three candidates for membership and three additional European countries non-EU members. The assessment of radiation therapy capacity in Europe was performed using the IAEA Directory of Radiotherapy Centres (DIRAC) and Globocan-2002. DIRAC is an electronic database maintained by the IAEA since 1995 that describes radiotherapy facilities worldwide.
Results: Europe has a total of 1109 radiotherapy centres registered in DIRAC. These centres operate a total of 2608 teletherapy machines of which 2119 are medical accelerators and 489 are cobalt-60 units. In addition, DIRAC contains data on 766 brachytherapy systems.
Distribution: the countries with the highest number of radiotherapy centres are Germany (214) and France (203) the largest number of teletherapy machines (444) is in France and 439 in Germany. Five countries have one radiotherapy centre and three countries operate with two teletherapy machines. The level of *fragmentation* is variable, with countries that tend to operate an average of 8 teletherapy machines/centre while others tend to have many centres operating 1−2 teletherapy machines. There is an average of 4.44 teletherapy machines per million population, from the lowest of 1.3/million to the highest 9.18/million. Using crude cancer incidence data the average indicator of teletherapy machines per 1000 cancer cases/year is 1.15 for Europe, with the lowest in Estonia (0.38) and the highest in Denmark and Ireland (1.99).
From the staffing viewpoint (more uncertain to quantify) a total of 5046 radiation oncologists, 2717 medical physicists and 7766 radiation therapy technologists are registered in DIRAC.
Nine facilities offer treatment with proton beams or heavy ions. An additional 10 facilities are under construction or upgrading.
Conclusions: The value of an up-to-date database on radiotherapy capacity facilitates projections and planning of radiation oncology services at a national or regional level.
This study was conducted with the sponsorship of the European Commission under the EUNICE project.

2023 POSTER

The impact of 3 dimensional CT planning on radiotherapy for bone metastases

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Background: Fluoroscopy based two dimensional (2D) radiotherapy (RT) planning for bone metastases (BM) is standard practice in many RT centers. Use of 3 dimensional (3D) CT based RT planning is more resource intensive but may provide improved information on disease extent and dose delivery. This report describes the impact of 3D CT based planning on defining the target, and the conformity (shape) of RT dose to the BM target.
Materials and Methods: A prospective study was designed to evaluate the impact of 3D versus 2D based planning for palliative RT of BM using either a single beam or simple 2 beam technique. After clinical assessment and review of diagnostic imaging, an RT planning CT scan was obtained. Oncologists defined two sets of treatment fields. First, using digitally reconstructed radiographs only to represent 2D planning, the study 2D treatment fields were defined. The full 3D CT planning scan was then reviewed, followed by target delineation and actual treatment field generation to represent 3D planning. Changes to the intended target, reasons for change, indices to describe the relative target coverage and dose to normal tissue were compared.
Results: Fifty-one patients receiving RT to 57 sites were accrued. 29/57 (51%) cases were spine metastases. Oncologists documented a change in the intended anatomical target after viewing the 3D data in 31/57 (54%) cases. The reasons for change included extent of local disease (22), significant distant disease not apparent on diagnostic tests (2), shielding modification due to concern of proximity of the kidney to the target (1) and not specified (5). In one case, the degree of bone destruction seen on planning CT prompted an orthopedic consult and surgery. 3D plans were superior to 2D plans with improved target coverage (as measured by the mean target volume coverage factor; 93% vs 77%, $p < 0.001$), but only a trend for reduced dose to normal tissues was observed (as measured by the healthy tissue overdose factor; 2.56 for 3D vs 4.87 for 2D, $p = 0.12$).
Conclusions: 3D CT planning in patients with bone metastases provides improved anatomical details that can influence clinical decision-making and target delineation. It may also permit superior RT dose to the target and limit dose to normal tissues. Technological advances have the potential to improve the effect of palliative radiotherapy for bone metastases and requires further study.

2024 POSTER

Acute radiation effects on cardiac function detected by strain rate imaging in breast cancer patients

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Background: Strain rate imaging (SRI) is an echocardiographic technique that has been shown to detect changes in regional cardiac function before they are notable by conventional techniques. SRI allows measurement of the regional myocardial deformation (strain, S) and deformation rate (strain rate, SR). In this prospective study we assessed the radiotherapy (RT)-induced early changes in cardiac function in breast cancer patients by means of SRI, and correlated these changes with the heart radiation dose.
Methods: We included 20 left-sided breast cancer patients, receiving RT (50 Gy in fractions of 2 Gy) to the breast or chest wall. In 12 patients, the internal mammary lymph nodes were also irradiated. Ten right-sided breast cancer patients served as control. SRI data were obtained pre-RT, immediately post-RT and 2 months post-RT. S and SR were measured in the 18 left ventricular (LV) segments of each patient and the radiation dose to the different segments was calculated. SRI parameters were compared between pre- and post-RT measurements by analysis of variance with Bonferroni post-hoc analysis. Furthermore, the effect of potential confounding factors was tested by univariate analysis with respect to the decrease in S post-RT.
Results: Adequate measurement of S and SR could be done in 522 out of 540 LV segments. The mean dose to the LV in left- and right-sided patients was respectively 6.7 and 0.6 Gy. The mean dose to the apical, mid and basal LV segments in left-sided patients was respectively 12.8, 5.4 and 4.5 Gy. The median LV segmental dose in left-sided patients was 3 Gy. A reduction in S was observed immediately and at 2 months post-RT ($p = 0.0002$) in left-sided patients, but not in right-sided patients. Within the left-sided patient group, S and SR were reduced post-RT for the apical LV segments ($p < 0.0001$ and $p = 0.011$), in contrast to the mid and basal segments. The decrease in S remained significant 2 months post-RT ($p < 0.001$), whereas SR went back to baseline values. We also observed that segments exposed to more than 3 Gy, showed a decrease in S immediately and at 2 months post-RT ($p = 0.0003$), in contrast to segments receiving less than 3 Gy. Furthermore, significant correlations were found between the decrease in S post-RT and the side of irradiation, the BMI, the mean LV segmental dose and the volume of the LV receiving 30 Gy.
Conclusions: SRI allowed the detection of a dose-related regional decrease in myocardial function early after RT.

2025 POSTER

Single institution preliminary experience on dose reduction to organs at risk in thoracic radiotherapy for patients enrolled in EORTC-GELA-IIL H10 study protocol on early stage Hodgkin's Lymphoma

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Background: to retrospectively evaluate the impact of Involved Nodes Radiation Therapy (INRT) on dose reduction to different organs at risk in patients enrolled by our Institution in the EORTC-GELA-IIL H10 protocol for stage I-IIA supra-diaphragmatic Hodgkin's Lymphoma.
Materials and Methods: Nine patients were included in the study, and 5 (4 females and 1 male) randomized to the standard arm A (3−4 ABVD cycles plus INRT 30 Gy independently from PET findings after the first 2

cycles). In order to estimate the entity of dose reduction, we compared for every patient INRT dose distribution profiles in different organs with dose profiles of classic involved fields, as if patients were treated outside the trial, and with mantle field as "historical" example of extended fields approach. All patients had mediastinal involvement in at least one nodal station at diagnosis, 4/5 patients had supraclavicular involvement and 3 middle-upper neck involvement. No axillary localizations were present. INRT fields were contoured following EORTC guidelines specifically designed for H10 trial (Girinsky et al, 2007–2008). A classic AP-PA parallel opposing fields technique with personalized shaped blocks was employed. Organs at risk were: breast (bilateral, as a whole organ), lung (bilateral, as a whole organ), thyroid gland, coronary arteries (origin). Breasts were considered at risk only in female patients (4/5). Mean dose and dose received by 50% of the volume (D50) were selected as parameters for comparison for every organ and calculated separately, then average values were taken into account for final comparison.
Results: Average dose reductions (expressed in percentage for mean dose and for D50) for breast, lung, thyroid gland and coronary arteries are shown in table I.

Table I

	Dose reduction	
	INRT vs. IFRT	INRT vs. MF
Breast:		
Mean dose	57.1%	57.3%
D50	44.1%	73.5%
Lung:		
Mean dose	38.8%	58.2%
D50	65.5%	88%
Thyroid gland:		
Mean dose	25.6%	41.5%
D50	9.1%	30%
Coronary artery:		
Mean dose	2.2%	22.2%
D50	1%	21%

Conclusions: As preliminary findings, our data suggest that for breast and lung a clear advantage in terms of global dose reduction is evident with INRT if compared with IFRT (and intuitively greater if compared with a traditional mantle field approach). The potential benefit for thyroid gland and coronary arteries sparing is not so evident, and has to be evaluated prospectively in a larger series. In order to spare these central structures, probably a different technical approach including IMRT and various IGRT options for thoracic radiotherapy is needed.

2026 POSTER

Response of melanocytes to low doses of fractionated radiotherapy

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Background: Low doses of ionizing radiation will inhibit cell division of the basal kreatinocytes of human epidermis, and reduce the ability to maintain the normal amount of cells in the germinal cell layer. Previously a hypersensitivity to doses below 0.3 Gy was determined by our group for DNA double-strand breaks, growth arrest and apoptosis throughout a treatment course of 7 weeks. The aim of this study is to determine the melanocyte response by molecular markers to daily low doses of radiation and to establish whether hyper-radiosensitivity also occurs for this cell type.
Material and Methods: Skin punch biopsies from 33 patients treated for prostate cancer with radiotherapy were used. Sampling of biopsies for each patient was performed before treatment and after 1 or 6.5 weeks into the radiotherapy course. The daily doses per fraction were about 0.1, 0.2, 0.45 and 1.1 Gy at the different areas of the exposed skin where biopsies were taken. The number of melanocytes per mm of the basal membrane was determined using immunohistochemical staining with eosin-PAS, ΔNP63-negative, MITF and Bcl-2. Three paraffined sections from each biopsy were assessed for every marker. The dose-response relationships were determined from the mean values of each staining versus fraction size.
Results: Both after 1 week and 6.5 weeks of radiotherapy an increase in the numbers of eosin-PAS, MITF and Bcl-2 stained melanocytes were observed. Small fraction doses of 0.04 Gy had a trigger effect, causing the melanocytes to reveal a more distinct morphology in eosin-PAS and express higher levels of MITF and Bcl-2. The number of ΔNP63-negative cells was constant, and independent of fraction size.
Conclusions: Melanocytes are radioresistant to low doses of radiotherapy over 7 weeks. Several molecular markers indicate an induced radioresistance. An effective DNA damage response of melanocytes preserves their cell number intact.

2027 POSTER

4D FDG-PET/CT combined with diffusion weighted MRI for planning of stereotactic radiation therapy of liver metastasis

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Background: Stereotactic radiotherapy is a highly effective method for treatment of liver metastasis in not operable patients. Although MRI and CT are standard imaging modalities for therapy planning, it is frequently difficult to define an exact target volume based on these methods. PET and diffusion weighted MRI (DWMRI) may help to improve the accuracy of target volumes. Aim of this study was to investigate feasibility and value of coregistration of respiratory gated PET-CT in treatment position and DWMRI.
Methods: 11 patients assigned to stereotactic body radiation therapy of liver metastases were examined by standard planning contrast enhanced CT and MRI scans, 4D FDG-PET/CT using respiratory gated PET and CT in treatment position and by diffusion weighted MR sequences. DWMRI data was acquired in breath hold (end-expiration). Immobilization for image acquisition (CT, PET-CT) and treatment was carried out in a vacuum couch with a low-pressure foil as used for regular SBRT. The different imaging studies were fused on a BrainLab workstation (iPlan net). The quality of the fusion was rated on a scale from 1 (very good) to 5 (bad). Gross tumor volumes were defined using conventional morphological imaging (CT, T1 and T2 weighted MRI) (Vcon), visual PET information (Vpet) and all modalities combined (Vcom). A composite volume from all different GTV was then created.
Results: 15 lesions were identified, in 2 patients the diagnosis of liver metastases was not confirmed in FDG-PET. Optimal fusion could only be achieved in 20% of the patients. The tumor volumes differed significantly when contoured in contrast-enhanced CT or MR compared to FDG-PET. The mean Vcon was 40 ccm while the mean Vpet and Vcomb were 59 and 89 ccm respectively. Difference of the volumes were up to a factor of 3.5 between Vpet and V con (mean 0.9) and up to a factor of 4.8 between Vcon and V comb (mean 1.8).
Conclusions: Coregistration of imaging modalities due to anatomic colocalisation was most feasible when planning CT and PET-CT in treatment position was used. MRI acquired in end-expiration was difficult to fuse with the other imaging modalities. Using visual information of FDG-PET for GTV-delineation the GTV was significantly enlarged. Prior to decide about target volume adaption (expansion) due to additional information provided by functional MRI or PET quantitative analysis should be performed.

2028 POSTER

Second Cancer after Total Body Irradiation: a retrospective analysis of 773 patients

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Background: To retrospectively evaluate second cancer in a group of children and adults treated with TBI. The database includes late toxicities; this analysis focused on second cancers.
Materials/Methods: Between October 1984 and June 2002, 773 patients received TBI in their conditioning regimens prior to autologous or allogeneic stem cell transplantation (SCT). TBI was performed at the Léon Bérard Cancer Center -France. The median follow-up from TBI was 4 years (range 0–27.4 yrs). The study registers 347 deaths (45%). Among 773 patients, 259 survived longer than 4 years with regular follow-up. Median age of patients at the time of the TBI was 32.4 years (range 0.3−95). Median TBI dose was 1090 cGy (8−12 Gy)/3 fraction (fx)/3 days with 6 MV linear accelerator.
Results: A total of 39 second cancers were recorded with a 2.9 years median time-to-TBI (range 0.5−17.2 yrs). Thirty-three second cancers occurred among the 259 more than 4 years survivors. Second cancer distribution listed 5 haematological malignancies, 3 cutaneous malignancies, 2 brain cancers, 6 gastro-intestinal cancers, 3 head-and-neck