The 9th International Clinical Oncology Congress

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فیزیک پزشکی، تکنولوژی پرتودرمانی،
رادیوبیولوژی و پرستاری انکولوژی

29-31 January 2025
Olympic hotel,Tehran ,IRAN

Title: Latest Techniques in Breast Cancer Radiotherapy “Developments from 2024”

Content: Overview of the presentation's focus on recent advancements in radiotherapy for breast cancer treatment

Marzieh Lashkari MD
Associate Professor of Radiation Oncology
Iran Cancer Institute,Tehran University of Medical Sciences

Introduction

- Breast cancer is most prevalent cancer in world
- Breast cancer incidence is 2.2 million per year
- Breast cancer mortality rates higher in developing countries

- Dose Schedule
- Volume Of Treatment
- Techniques Of Radiotherapy

- Dose Schedule
- Volume Of Treatment
- Techniques Of Radiotherapy

Hypofractionated Radiation Therapy (HFRT)

- Definition: Delivers higher doses of radiation per session over a shorter period.

- Benefits: Comparable efficacy to conventional fractionation with reduced treatment duration and potential for fewer side effects.

- Evidence: Studies like the UK START trials have demonstrated similar local control and survival rates with HFRT compared to conventional fractionation [Haviland JS et al., Lancet Oncol. 2013].

- A historical regimen of 25–28 fractions over 6 weeks was adopted for radiotherapy (RT) following breast-conserving surgery (BCS) and total mastectomy.

- An early assumption that breast cancer cell lines might be more sensitive to fractional doses than acute skin reactions and other squamous carcinomas led to development of the hypofractionated RT (HypoRT) approach which elevated fractional dose up to 3 Gy with reduced total dose/fractions, for obtaining radiobiological equivalence to a traditional regimen of 50–50.4 Gy/25-28f.

Hypofractionated Radiation Therapy (HFRT)

1998-2002

START A

- 2236 patients: 41.6 or 39Gy/13fr
- (pT1-3a pN0-1 M0)
- Women were eligible if they were aged over 18 years, did not have an immediate surgical reconstructio n

1998-2002

START B

- 2215 patients: 40/15
- (pT1-3a pN0-1 M0)
- over 18 years, did not have an immediate reconstructio n

2009- 2014

Danish Breast Cancer Group (DBCG) HYPO

- 1882 patients
- T1-2 N0-N1(mic)

Hypofractionated Radiation Therapy (HFRT)

	START pilot	START A	START B	OCOG	Beijing	Chinese	MDACC	DBCG Hypo	TROG 07.01
Year	1986–1998	1998–2002	1999–2001	1993–1996	2008–2016	2010–2015	2011–2014	2009–2014	2007–2014
n	1,410	2,236	2,215	1,234	820	734	287	1,854	1,608
Standard arm[a)]	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx
Test arm[a)]	42.9 Gy/13 fx (5)	41.6 Gy/13 fx (5)	40 Gy/15 fx (3)	42.5 Gy/16 fx (3)	43.5 Gy/15 fx (3)	43.5 Gy/15 fx (3)	42.5 Gy/16 fx (3)	40 Gy/15 fx (3)	42.5 Gy/16 fx (3)
	39 Gy/13 fx (5)	39 Gy/13 fx (5)							

Hypofractionated Radiation Therapy (HFRT)

	START pilot (50 Gy vs. 42.9 Gy vs. 39 Gy)	START A (50 Gy vs. 41.6 Gy vs. 39 Gy)	START B (50 Gy vs 40 Gy)	OCOG (50 Gy vs 42.5 Gy)	Beijing (50 Gy vs. 43.5 Gy)	Chinese (50 Gy vs. 43.5 Gy)	MDACC (50 Gy vs. 42.5 Gy)	DBCG Hypo (50 Gy vs. 40 Gy)	TROG 07.01 (50 Gy vs. 42.5 Gy)
Follow-up (yr)	9.7	9.3	9.9	12	4.9	6.1	4.1	7.3	6.6
5-yr IBTR									
Standard	7.9	3.4	3.3	3.2	8.1 (LRR)	1.2	98 (LRFS)		5.1
Test	7.1	3.1	2	2.8	8.3 (LRR)	2	99 (LRFS)		5.1
	9.1	4.4							
10-yr IBTR									
Standard	12.1	6.7	5.2	6.7				3.3 (9-yr LRR)	
Test	9.6	5.6	3.8	6.2				3.0 (9-yr LRR)	
	14.8	8.1							

IBTR: Ipsilateral breast tumor relapse

Hypofractionated Radiation Therapy (HFRT)

- Given excellent IBTR control rates and toxicity profiles from existing data

HypoRT is an efficient, safe, and convenient treatment approach for breast cancer. The standard of care for adjuvant RT has shifted from 5–6 weeks of conventional fractionated RT to 3–4 weeks of HypoRT.

Ultrahypofractionated Radiation Therapy (UHFRT)

- Definition: Delivers higher doses of radiation per session over a shorter period.

- Benefits: Comparable efficacy to conventional and hypofractionation with reduced treatment duration and potential for fewer side effects.

- uHWBRT arose in centers that have logistics problems in treatment length and costs

UltrahypofractionatedRadiation Therapy (UHFRT)

1998-2002	**1998-2002**	**2009- 2014**	**2004-2007**	**2011-2014**
START A	**START B**	**Danish Breast Cancer Group (DBCG) HYPO**	**FAST Trial**	**Fast-Forward Trial**
• 2236 patients: 41.6 or 39Gy/13fr • (pT1-3a pN0-1 M0) • Women were eligible if they were aged over 18 years, did not have an immediate surgical reconstructio n	• 2215 patients: 40/15 • (pT1-3a pN0-1 M0) • over 18 years, did not have an immediate reconstructio n	• 1882 patients • T1-2 N0-N1(mic)	• 915 women (pT1-2 pN0) • Women ≥ 50 years of age	• 4096 patients • (pT1-3, pN0-1, M0) • aged at least 18 years

Ultrahypofractionated Radiation Therapy (UHFRT)

	START pilot	START A	START B	OCOG	Beijing	Chinese	MDACC	DBCG Hypo	TROG 07.01	FAST	FAST-Forward
Year	1986–1998	1998–2002	1999–2001	1993–1996	2008–2016	2010–2015	2011–2014	2009–2014	2007–2014	2004–2007	2011–2014
n	1,410	2,236	2,215	1,234	820	734	287	1,854	1,608	915	4,096
Standard arm[a)]	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	50 Gy/25 fx	40 Gy/15 fx (3)
Test arm[a)]	42.9 Gy/13 fx (5)	41.6 Gy/13 fx (5)	40 Gy/15 fx (3)	42.5 Gy/16 fx (3)	43.5 Gy/15 fx (3)	43.5 Gy/15 fx (3)	42.5 Gy/16 fx (3)	40 Gy/15 fx (3)	42.5 Gy/16 fx (3)	30 Gy/5 fx (5)	27 Gy/5 fx (1)
	39 Gy/13 fx (5)	39 Gy/13 fx (5)								28.5 Gy/5 fx (5)	26 Gy/5 fx (1)

Ultrahypofractionated Radiation Therapy (UHFRT)

	START pilot (50 Gy vs. 42.9 Gy vs. 39 Gy)	START A (50 Gy vs. 41.6 Gy vs. 39 Gy)	START B (50 Gy vs 40 Gy)	OCOG (50 Gy vs 42.5 Gy)	Beijing (50 Gy vs. 43.5 Gy)	Chinese (50 Gy vs. 43.5 Gy)	MDACC (50 Gy vs. 42.5 Gy)	DBCG Hypo (50 Gy vs. 40 Gy)	TROG 07.01 (50 Gy vs. 42.5 Gy)	FAST (50 Gy vs. 30 Gy vs. 28.5 Gy)	FAST-Forward (40 Gy vs. 27 Gy vs. 26 Gy)
Follow-up (yr)	9.7	9.3	9.9	12	4.9	6.1	4.1	7.3	6.6	9.9	6.0
5-yr IBTR											
Standard	7.9	3.4	3.3	3.2	8.1 (LRR)	1.2	98 (LRFS)		5.1	0.7	2.1
Test	7.1	3.1	2	2.8	8.3 (LRR)	2	99 (LRFS)		5.1	1.0	1.7
	9.1	4.4								0.4	1.4
10-yr IBTR											
Standard	12.1	6.7	5.2	6.7				3.3 (9-yr LRR)		0.7	
Test	9.6	5.6	3.8	6.2				3.0 (9-yr LRR)		1.4	
	14.8	8.1								1.7	

Ultra-hypofractionated whole breast adjuvant radiotherapy

-single experience with 271 patients treated with 3D and IMRT technique

-T1-T3 invasive BC, no or limited axillary involvement, age ≥ 65 years or women with commuting difficulties or disabling diseases.

Ultra-hypofractionated whole breast adjuvant radiotherapy in the real-world setting : single experience with 271 elderly/frail patients treated with 3D and IMRT technique,Maria Alessia Zerella,Radiotherapy and Oncology,2021 April

-The only severe acute toxicity (G3) at the end of RT was erythema (0.4%), registered in the 3DCRT group. With 18 months of median follow-up, severe early-late toxicity (G3) was reported in terms of fibrosis and breast retraction, both with an incidence of 1.4%, mostly in the 3DCRT group.

-At 3 years, disease-free survival and overall survival were 94.9% and 97.8%, respectively

Ultra-Hypofractionation for Whole-Breast Irradiation in Early Breast Cancer: Interim Analysis of a Prospective Study

-A total of 70 patients were treated. Fifty-nine were treated with the 26 Gy/5 fr/1 w and 11 with the 28.5 Gy/5 fr/5 ws schedule

-IMRT for all patients

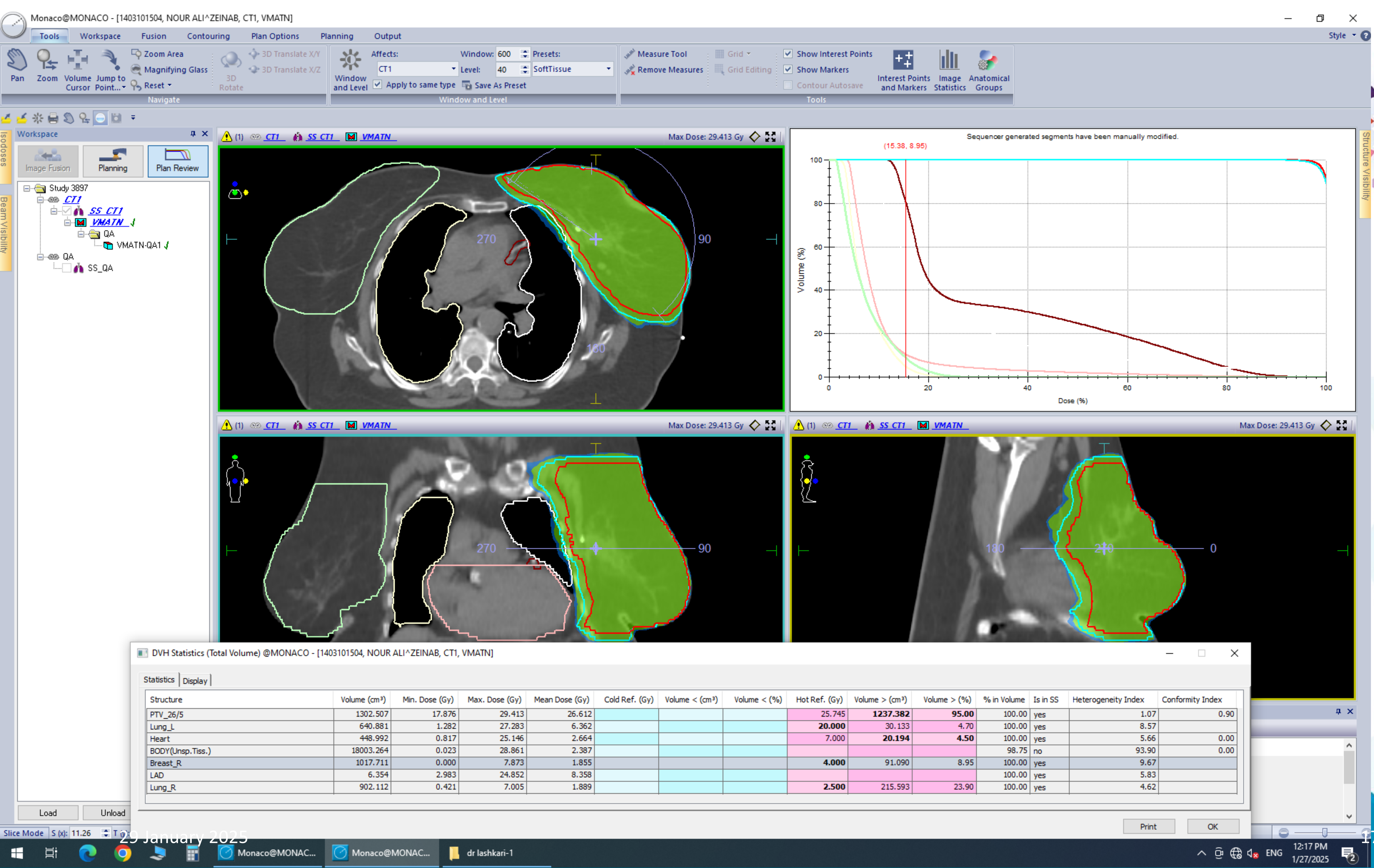
-Median age was 67 and 70 in the two groups

-Most of the patients had a clinical T1N0 disease

- Ultra-Hypofractionation for Whole-Breast Irradiation in Early Breast Cancer: Interim Analysis of a Prospective Study,Valeria Sigaudi,Biomedicines 2022 oct

-Maximum detected acute skin toxicities were grade 2 erythema (6.7%), grade 2 induration (4.4%), and grade 2 skin colour changes

-No early IBTR was observed.



Structure	Volume (cm³)	Min. Dose (Gy)	Max. Dose (Gy)	Mean Dose (Gy)	Cold Ref. (Gy)	Volume < (cm³)	Volume < (%)	Hot Ref. (Gy)	Volume > (cm³)	Volume > (%)	% in Volume	Is in SS	Heterogeneity Index	Conformity Index
PTV_26/5	1302.507	17.876	29.413	26.612				25.745	**1237.382**	**95.00**	100.00	yes	1.07	0.90
Lung_L	640.881	1.282	27.283	6.362				**20.000**	30.133	4.70	100.00	yes	8.57	
Heart	448.992	0.817	25.146	2.664				7.000	**20.194**	**4.50**	100.00	yes	5.66	0.00
BODY(Unsp.Tiss.)	18003.264	0.023	28.861	2.387							98.75	no	93.90	0.00
Breast_R	1017.711	0.000	7.873	1.855				**4.000**	91.090	8.95	100.00	yes	9.67	
LAD	6.354	2.983	24.852	8.358							100.00	yes	5.83	
Lung_R	902.112	0.421	7.005	1.889				**2.500**	215.593	23.90	100.00	yes	4.62	

- Dose Schedule
- Volume Of Treatment
- Techniques Of Radiotherapy

Accelerated partial breast irradiation (APBI)

- Patient selection criteria

1	Age ≥ 50 years
2	Tumor size ≤ 2 cm
3	Invasive non-specific type of cancer, infiltrative non-specific type of cancer
4	Grade I or II of malignancy
5	The absence of lymph node lesions and distant metastases, N0 and M0
6	Surgical margin: cancer not exposed, ≥ 3 mm
7	Luminal A (ER+, PR+, Her2/neu+1) and luminal B (ER+/, PR+/, Her2/neu+1)
8	Negative results for mutations of BRCA genes
9	The Ki-67 ≤ 40%

Accelerated Partial Breast Irradiation for Early-Stage Invasive Lobular Carcinoma

- Of 1248 patients treated from 2010 to 2022 who underwent APBI, the study cohort comprised 132 (11%) who had ILC, either exclusively or mixed with another histology

- Median age 63/Median tumor size was 1.1 cm/ all ER positive disease (99%) and hormone therapy (91%)/sentinel node biopsy (89%) with the remainder having no axillary surgery.

- All patients received external beam APBI to 40 Gy in 10 daily fractions.

- Outcomes of interest included local recurrence (LR) and overall survival (OS).

- **Results**

- A median follow-up was 39 months

- 4-year LR rate of 3%(Both events arose in patients with mixed lobular histology (none arose in patients with pure ILC)

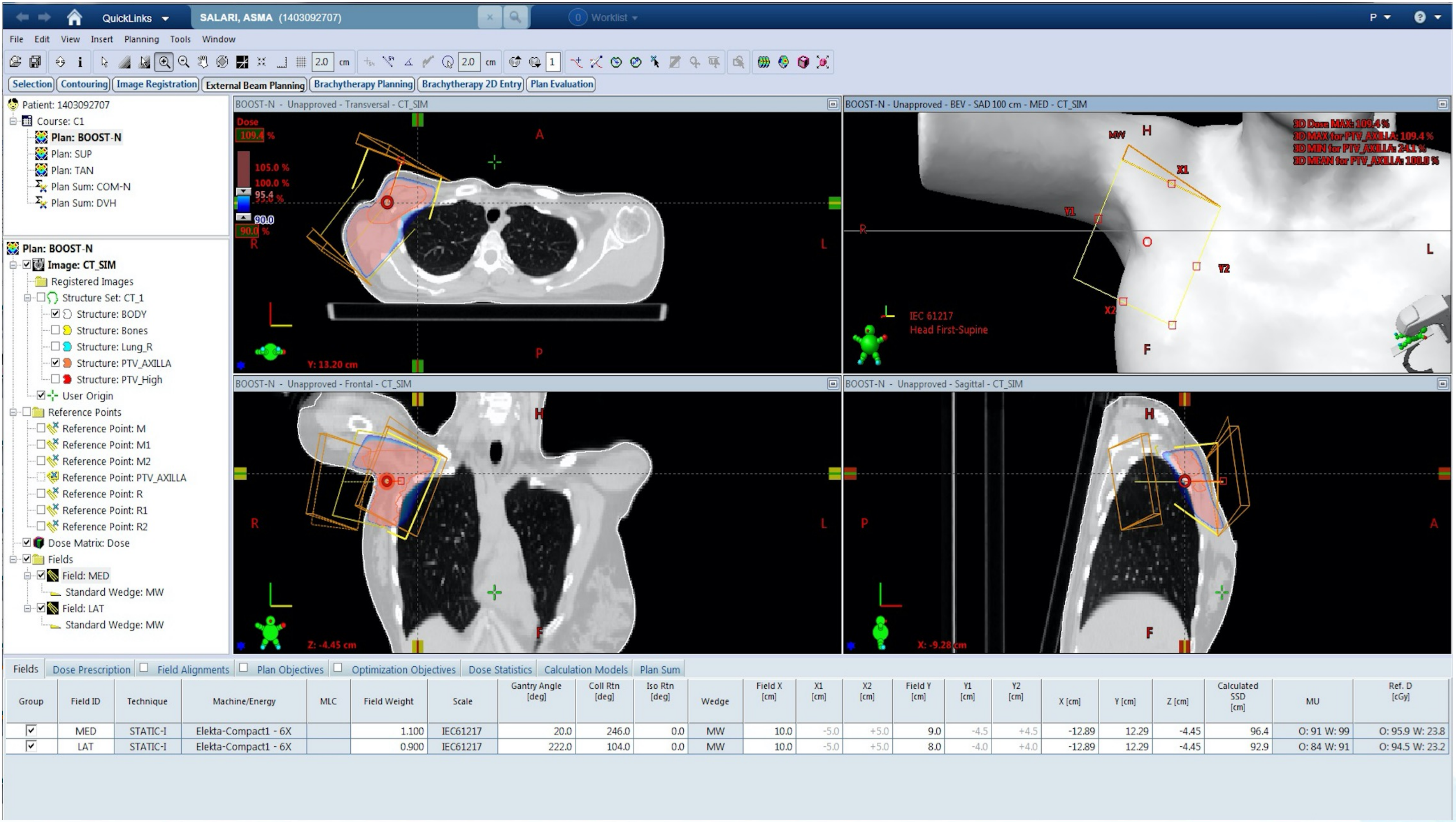
- No regional or distant recurrences were observed

- OS was excellent(98%)

Accelerated Partial Breast Irradiation for Early-Stage Invasive Lobular Carcinoma ,Lior Z Braunstein,ijrobp 2024 oct

Axillary Boost

- In the population of patients with extranodal extension(ENE), the majority of failures are distant with no isolated LRFs. Locoregional failures are the highest in the IMN + ax/SCV group (∼40%). treatment escalation should be considered for these patients.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Dose
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Fields
Dose Prescription
Field Alignments
Plan Objectives
Optimization Objectives
Dose Statistics
Calculation Models
Plan Sum
Group | Field ID | Technique | Machine/Energy | MLC | Field Weight | Scale | Gantry Angle [deg] | Coll Rtn [deg] | Iso Rtn [deg] | Wedge | Field X [cm] | X1 [cm] | X2 [cm] | Field Y [cm] | Y1 [cm] | Y2 [cm] | X [cm] | Y [cm] | Z [cm] | Calculated SSD [cm] | MU | Ref. D [cGy]
✓ | MED | STATIC-I | Elekta-Compact1 - 6X | | 1.100 | IEC61217 | 20.0 | 246.0 | 0.0 | MW | 10.0 | -5.0 | +5.0 | 9.0 | -4.5 | +4.5 | -12.89 | 12.29 | -4.45 | 96.4 | O: 91 W: 99 | O: 95.9 W: 23.8
✓ | LAT | STATIC-I | Elekta-Compact1 - 6X | | 0.900 | IEC61217 | 222.0 | 104.0 | 0.0 | MW | 10.0 | -5.0 | +5.0 | 8.0 | -4.0 | +4.0 | -12.89 | 12.29 | -4.45 | 92.9 | O: 84 W: 91 | O: 94.5 W: 23.2

- Dose Schedule
- Volume Of Treatment
- Techniques Of Radiotherapy

Radiotherapy Techniques

- IMRT
- VMAT
- Proton beam
- SBRT
- DIBH

Intensity-Modulated Radiation Therapy (IMRT)

- Definition: Uses advanced technology to modulate the radiation dose, conforming to the shape of the tumor

- Benefits: Allows for higher doses to the tumor while sparing normal tissues, potentially reducing side effects.

Comparative Effectiveness Analysis of 3D-Conformal Radiation Therapy Versus Intensity Modulated Radiation Therapy (IMRT) in a Prospective Multicenter Cohort of Patients With Breast Cancer(university of Michigan)

- **Conventional fractions**

-1185 patients treated with 3DCRT

650 (54.9%) experienced acute toxicity (moderate-severe pain or moist desquamation)

-774 treated with highly segmented forward-planned IMRT, 458 (59.2%) experienced acute toxicity

-580 treated with inverse-planned IMRT, 245 (42.2%) experienced acute toxicity

- **Hypofraction**

- 1296 patients treated with 3DCRT, 432 (33.3%) experienced acute toxicity

-709 treated with highly segmented forward-planned IMRT, 227 (32.0%) experienced acute toxicity

-623 treated with inverse-planned IMRT, 164 (26.3%) experienced acute toxicity

study found a significant benefit from inverse-planned IMRT compared with 3DCRT in reducing acute toxicity of breast radiation therapy

- Comparative Effectiveness Analysis of 3D-Conformal Radiation Therapy Versus Intensity Modulated Radiation Therapy (IMRT) in a Prospective Multicenter Cohort of Patients With Breast Cancer,Reshma Jagsi MD et al , International Journal of Radiation Oncology*Biology*Physics Volume 112, Issue 3 ,1 March 2022

IMRT in patients with Immediate prosthesis implantation after mastectomy

-104 patients undergoing IMRT after MRM for breast cancer

-Radiotherapy was performed on the ipsilateral chest wall, supraclavicular and infraclavicular lymph nodes at a dose of 50Gy/2Gy/25f.)

The patients were divided into two groups according to whether undergoing breast reconstruction.

-first group, all patients underwent immediate implant-based breast

-Patients in the second group received modified radical mastectomy without breast reconstrution.

- The first group was named IBBR group with 46 patients.
- The second group was named non-reconstruction group with 58 patients

➢ Radiotherapy dosimetry and radiotherapy related complications of immediate implant-based reconstruction after breast cancer surgery Yu Zhang et al, frontiers in oncology,2023 oct

-Implant-related complications during follow-up:

- grade1-2 capsular contracture occurred in17.4% patients in the IBBR group
- wound infection occurred in 11.0%
- skin necrosis occurred in 6.5%
- No implant rupture occurred
- implant loss occurred in two patients after completion of radiotherapy due to infection, and the reconstruction failure rate was 4.3%

With the advancement of radiotherapy technology,IBBR is a reasonable option for patients who need radiotherapy after modified radical mastectomy.

Volumetric-Modulated Arc Therapy (VMAT)

- Definition: Uses advanced technology to modulate the radiation dose, conforming to the shape of the tumor

- Benefits: A rotational form of IMRT and allows for higher doses to the tumor while sparing normal tissues, potentially reducing side effects.

Three-dimensional conformal radiotherapy (3D-CRT) vs. volumetric modulated arc therapy (VMAT)

-All plans fulfilled the criterium for PTV V95%≥ 95%.

-The PTV coverage, homogeneity, and conformity indices were significantly better for VMAT-DIBH.

- VMAT showed a significantly increased mean dose and V5Gy for all OARs, but reduced LAD Dmax by 15 Gy.
- For ipsilateral and contralateral lung and contralateral breast, the 3D-CRT DIBH method achieved the lowest values of Excess absolute risks

-The study shows that VMAT-DIBH provides better OAR sparing against high doses.
-The large low-dose-bath (≤5 Gy) is still a concern due to the fact that a larger volume of normal tissues exposed to lower doses may increase a radiation-induced risk of secondary cancer.

- Three-dimensional conformal radiotherapy (3D-CRT) vs. volumetric modulated arc therapy (VMAT) in deep inspiration breath-hold (DIBH) technique in left-sided breast cancer patients—comparative analysis of dose distribution and estimation of projected secondary cancer risk Iga Racka et al,Strahlenther Onkol,2022 July

VMAT vs IMRT

- VMAT plans significantly reduced treatment time and MU number when compared with IMRT in patients of left-sided breast cancer after modified radical mastectomy

- VMAT were associated with slightly advantage in terms of heart and coronary arteries sparing.

- Similar PTV coverage and sparing of other normal tissues were observed between these 2 techniques.

- VMAT is a promising technique in the treatment of left-sided breast cancer

➢ Dosimetric comparison between intensity modulated radiotherapy and volumetric-modulated arc therapy in patients of left-sided breast cancer treated with modified radical mastectomy,Rui Wang et al,Medicine (Baltimore). 2022 Jan

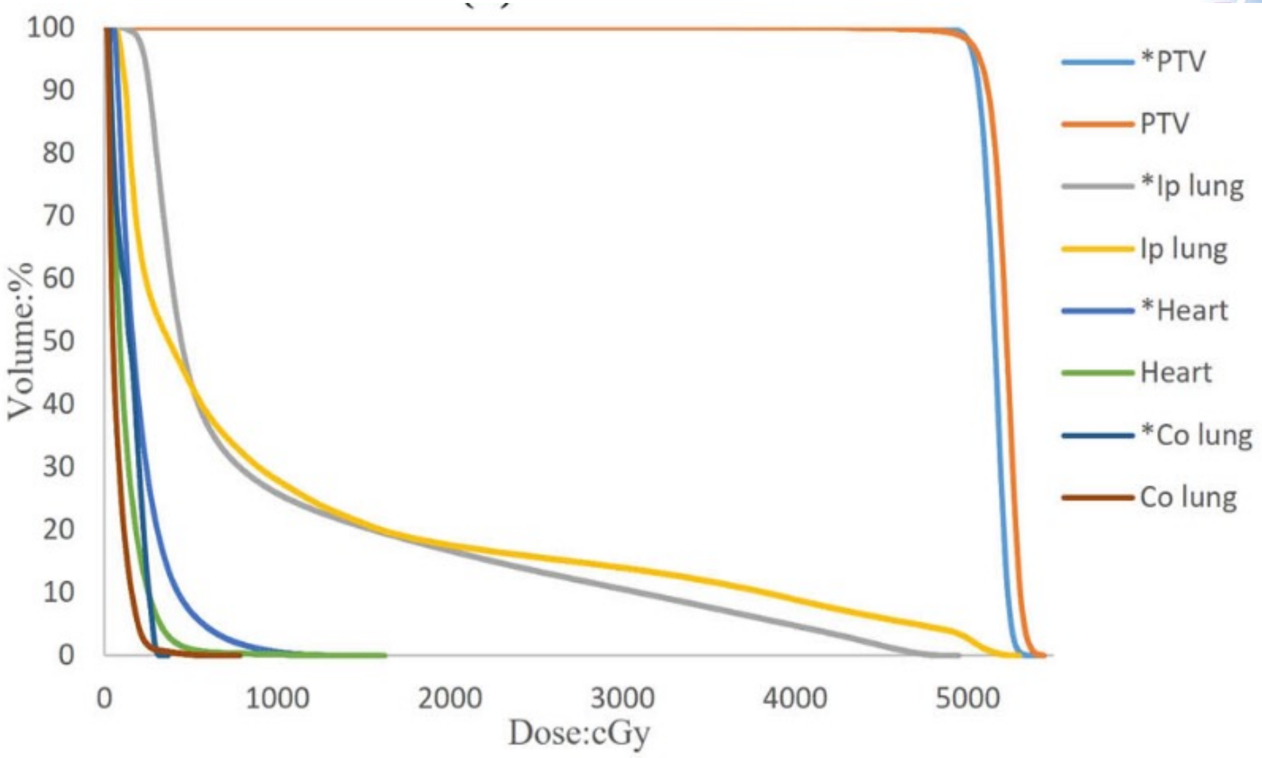
Comparison of plan quality between VMAT and IMRT for breast cancer

Breast conserving surgery: (a)

- *V* 50Gy of PTV for both IMRT and VMAT are 98%, but the homogeneity of the VMAT plan is better than that of the IMRT plan.

- For the ipsilateral lung, *V* 20Gy, *V* 30Gy, and mean dose of VMAT plan are better than those of IMRT plan, and *V* 5Gy is slightly higher.

- The doses to heart and contralateral lung of the VMAT plan are higher than those of the IMRT plan, but they are far less than the dose limitation.

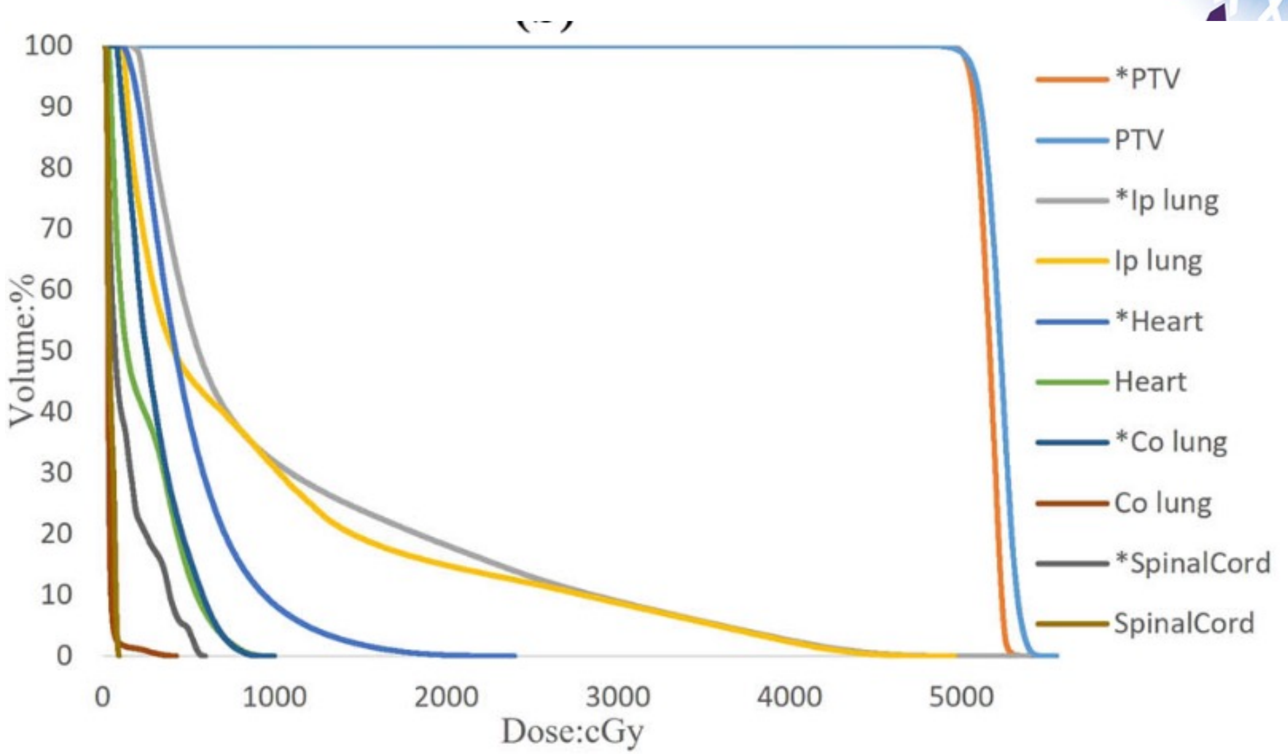


➢ Comparison of plan quality and robustness using VMAT and IMRT for breast cancer,Chuou Yin et al, the journal Open Physics ,2024

Comparison of plan quality between VMAT and IMRT for breast cancer

Post mastectomy: (b)

- The *V* 50Gy of PTV for VMAT plan and IMRT plan are 99.1 and 99.0%, respectively. The homogeneity of the VMAT plan is better than the IMRT plan.
- For the ipsilateral lung, the volume of VMAT plan is higher than that of IMRT plan when the dose is less than 1,000 cGy. However, the opposite result is found when the dose is between 1,000 and 3,000 cGy. In the high-dose region (>3,000 cGy), the DVH curves of the two plans almost overlapped.
- The doses to heart, contralateral lung, and spinal cord in VMAT plan are higher than those in IMRT plan, but they are lower than their dose limitations.



➢ Comparison of plan quality and robustness using VMAT and IMRT for breast cancer,Chuou Yin et al, the journal Open Physics ,2024

Beam	Description	Field ID	Visible	Delivery	Treatment ...	Modality	Algorithm	Energy	MU / Fx	SSD (cm)	Isocenter Loca...	X (cm)	Y (cm)	Z (cm)
1	ARC1	101	☐	VMAT	VERSAHD1	Photon	Monte Carlo	6.0 FFF	627.58	78.14	Setup Reference Point	4.00	-43.79	6.00
3	ARC2	102	☑	VMAT	VERSAHD1	Photon	Monte Carlo	6.0 FFF	711.90	78.14	Setup Reference Point	4.00	-43.79	6.00
4	ARC3	103	☑	VMAT	VERSAHD1	Photon	Monte Carlo	6.0 FFF	669.41	98.52	Setup Reference Point	4.00	-43.79	6.00
5	ARC4	104	☐	VMAT	VERSAHD1	Photon	Monte Carlo	6.0 FFF	708.06	98.52	Setup Reference Point	4.00	-43.79	6.00

Structure	Volume (cm³)	Min. Dose (Gy)	Max. Dose (Gy)	Mean Dose (Gy)	Cold Ref. (Gy)	Volume < (cm³)	Volume < (%)	Hot Ref. (Gy)	Volume > (cm³)	Volume > (%)	% in Volume	Is in SS	Heterogeneity Index	Conformity Index
CTV TOTAL	2549.694	17.389	58.384	50.388							100.00	yes	1.15	0.70
Lung_R	854.511	4.293	48.966	16.394				**20.000**	236.753	27.71	100.00	yes	5.68	0.00
Lung_L	701.550	4.297	49.038	15.270				**20.000**	180.262	25.69	100.00	yes	5.35	0.00
Heart	423.042	3.792	43.534	5.924							100.00	yes	2.16	0.00
CTV_LEFT	1390.755	18.723	58.384	50.379							100.00	yes	1.16	0.37

Proton Beam Therapy (PBT)

- Definition: Uses protons instead of X-rays, allowing for more precise targeting of tumors

- Benefits: Reduced radiation dose to surrounding normal tissues, potentially lowering the risk of side effects.

  - Evidence: Emerging data suggest benefits in reducing cardiac and lung exposure, particularly in left-sided breast cancer [MacDonald SM et al., Int J Radiat Oncol Biol Phys. 2013]

Stereotactic Body Radiation Therapy (SBRT)

- Definition: Delivers very high doses of radiation in a few fractions with high precision.

- Benefits: Potential for shorter treatment courses and improved local control in selected oligometastatic cases.

➢ Evidence: Preliminary studies suggest SBRT may be effective for oligometastatic breast cancer, though more research is needed [Navarria P et al., Breast. 2018]

Deep Inspiration Breath Hold (DIBH):

- Definition: A technique where patients hold their breath during radiation delivery to increase the distance between the heart and the chest wall.

- Benefits: Reduces radiation exposure to the heart, decreasing the risk of cardiac toxicity.

> Evidence: Studies have shown significant reductions in heart dose with DIBH compared to free-breathing techniques [Swanson T et al., Pract Radiat Oncol. 2013]

Artificial Intelligence in Radiotherapy

- **Title:** AI is Enhancing Treatment Precision

- **Content:** Artificial intelligence is being utilized to improve imaging quality and enable real-time adjustments during radiotherapy, minimizing damage to healthy tissues and enhancing treatment outcomes.

1. Precision and Personalization:

- AI can enhance the precision of radiation therapy by improving tumor targeting and sparing healthy tissues. This is achieved through advanced imaging analysis and treatment planning algorithms.

- Personalized treatment plans can be developed by integrating patient-specific data, leading to potentially better outcomes and reduced side effects.

2. Efficiency and Workflow:

- AI can streamline the workflow in radiation oncology by automating routine tasks such as contouring of organs at risk and treatment planning, thereby reducing the workload on clinicians and minimizing human error.

3. Adaptive Radiation Therapy:

- AI can facilitate adaptive radiation therapy, where treatment plans are adjusted in real-time based on changes in tumor size, shape, and position during the treatment course.

Adding Immunotherapy to Radiation Therapy

1. Rationale:

- Combining immunotherapy with radiation therapy (RT) can potentially enhance the anti-tumor immune response. RT can increase the release of tumor antigens, which may be more effectively targeted by the immune system when combined with immunotherapy.

2. Clinical Evidence:

- Studies have shown that combining RT with immune checkpoint inhibitors (e.g., pembrolizumab, nivolumab) can improve outcomes in certain cancers, including breast cancer. This combination can lead to a synergistic effect, enhancing both local and systemic tumor control .

3.Clinical Trials:

- Ongoing clinical trials are investigating the efficacy and safety of combining RT with various immunotherapies in breast cancer. These trials aim to determine optimal dosing, timing, and sequencing of treatments to maximize therapeutic benefits while minimizing adverse effects.

Considerations and Challenges

1. Patient Selection:

- Not all patients may benefit equally from the combination of RT and immunotherapy. Biomarkers and genetic profiling can help identify patients

2. Toxicity Management:

- Combining RT with immunotherapy can increase the risk of immune-related adverse events. Close monitoring and management of these toxicities are crucial to ensure patient safety.

Conclusion:

- Advancements in radiation therapy for breast cancer, such as HFRT, APBI, PBT, DIBH, IMRT, and SBRT, offer promising options for improving treatment efficacy and reducing side effects.

- Ongoing research and clinical trials continue to refine these techniques, aiming to optimize outcomes for breast cancer patients.

- AI-assisted radiation therapy and the addition of immunotherapy to radiation therapy hold promise for improving outcomes in breast cancer treatment. However, careful consideration of patient selection, toxicity management, and cost is essential for the successful implementation of these advanced therapies.

Thanks for Your Attention