IRRADIATION WITH THE SBRT DIBH TECHNIQUE OF PATIENTS WITH LIVER CANCER UNDER THE CONTROL OF THE ALIGNRT SYSTEM

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INTRODUCTION

Four Versa HD (Elekta) medical linear accelerators and one Radixact (Accuray) tomotherapy machine are installed in the Holy Cross Cancer Center in Kielce, Poland. Two of the four accelerators are equipped with the AlignRT system delivered by VisionRT company. The standard use (for most patients) of the AlignRT system in our clinic is the irradiation of patients with breast cancer with the DIBH technique.

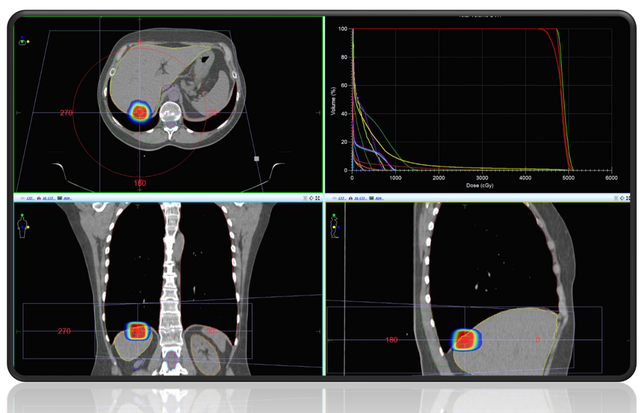
In the Holy Cross Cancer Center in Kielce (Poland) in the period from August 2021 (the beginning of the AlignRT system use) to November 2022, 45 patients received SBRT (Stereotactic Body Radiation Therapy). Seventeen patients were irradiated with the SBRT DIBH(Deep Inspiration Breath Hold) technique in such locations as the pancreas, lungs, ribs, and liver. All cases were diagnosed as metastases.

In the case of 5 patients with liver metastases, irradiation with the SBRT DIBH technique was used under the control of the AlignRT system. The treatment plans were calculated in the Monaco treatment planning system (TPS), where the Monte Carlo algorithm was used for calculations.

The study aims to estimate the differences in the GTV volumes for patients both with free breathing computed tomography (CT) and the same patients with the DIBH technique.

STEREOTACTIC BODY RADIATION THERAPY (SBRT)

Stereotactic Body Radiation Therapy (SBRT) is a technique due to high doses of radiation being delivered to the tumor (over 8 Gy per fraction) and with a very sharp dose gradient outside the tumor. SBRT involves the application of single high-dose radiotherapy or fractionated radiotherapy (usually from 1 to 8 fractions). The small target volume and the high dose of radiation delivered to the patient in one fraction require high precision and reproducibility of the patient's position on the day of treatment simulation. In this case, the Deep Inspiration Breath Hold (DIBH) method is helpful. Limiting the movement of the target is critical to achieving the required SBRT accuracy.



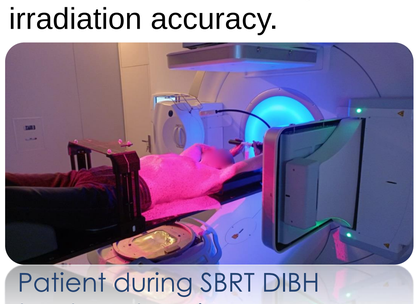
A screenshot from the Monaco treatment planning system of a patient with liver cancer irradiated with SBRT

This is especially true for the locations for which the targets (lesions) change it's position over time with the breathing cycle. Respiratory movements can significantly affect the mobility of tumors and tumor path is difficult to predict based on computed tomography alone (without the DIBH option).

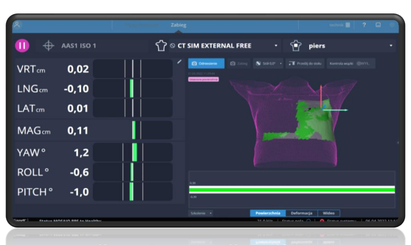
SURFACE GUIDED RADIATION THERAPY (SGRT)

Surface Guided Radiation Therapy (SGRT) is a technique of irradiation guided by the patient's external surface. At Holy Cross Cancer Center, two accelerators are equipped with the AlignRT system (VisionRT). AlignRT is the three-dimensional (3D) surface imaging system that allows monitoring of the patient's position in 3D mode before and during radiotherapy.

During each treatment session, the patient's position is compared to a reference external reference surface. The optimal treatment position is determined during treatment simulation. This reference surface is generated by importing skin contour from CT volume data generated in a treatment planning system. All differences in the position of the patient on the treatment table compared to the reference surface are displayed in the application. As a result, radiation is only delivered when the patient is correctly positioned, increasing patient irradiation accuracy.



Patient during SBRT DIBH treatment session



AlignRT application

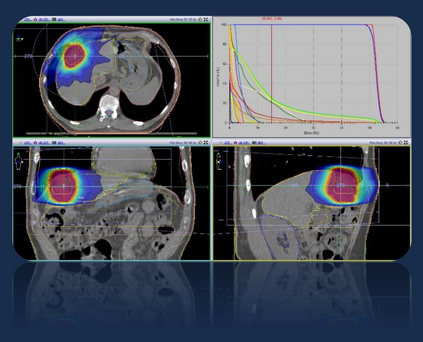
Real time coach (RTC)

BIBLIOGRAPHY

- J. Wendykier, B. Bekman, A. Grządziel, K. Ślosarek: Radioterapia sterowana obrazem powierzchni pacjenta AlignRT – pierwsze doświadczenia, Inżynier i Fizyk Medyczny, 7 (3), 2018, 203-210
- J.D.P. Hoisak , T. Pawlicki: The Role of Optical Surface Imaging Systems in Radiation Therapy, Semin Radiat Oncol, 28(3), 2018, 185-193
- N. Smith, I. Meir, G. Hale, R. Howe, L. Johnson, P. Edwards, D. Hawkes, M. Bidmead, D. Landau: Real-time 3D surface imaging for patient positioning in radiotherapy, Int J Radiat Oncol Biol Phys, 57, 2003, 187.
- G. Lawler: A review of surface guidance in extracranial stereotactic body radiotherapy (SBRT/SABR) for set-up and intra-fraction motion management, Technical Innovations & Patient Support in Radiation Oncology, 21, 2022, 23–26
- H. A. Al-Hallaq, L. Cerviño, A. N. Gutierrez, A. Havnen-Smith, S. A. Higgins, M. Kügele, L. Padilla, T. Pawlicki. N. Remmes, K. Smith, X. Tang, W. A. Tomé: AAPM task group report 302: Surface-guided radiotherapy, Med Phys., 49, 2022 82–112
- Quality assurance for nonradiographic radiotherapy localization and positioning systems: Report of Task Group 147
- UK Consortium (Version 6.1, January 2019)

CLINICAL CASES

Five patients with aged between 45 to 70 with liver metastases were treated with SBRT DIBH irradiation under the control of the AlignRT system.



All patients mentioned above were irradiated with the VMAT technique with the 6MV FFF beam without the use of a special immobilization (mattresses, etc.). Only T-holder and kneefix were used. The reproducibility of the patient's position for each cases patients was verified based on kVCBCT (Cone Beam Computed Tomography) studies. The plans were made in the Monaco treatment planning system, where the Monte Carlo algorithm was used for calculations.

The table shows general statistics for the patient with liver metastasis.

Patient:	Total dose [Gy]	Number fractions	$V_{PTV}\ [cm^3]$	Liver-GTV Dose to ≥700cc < 15Gy*	R100%	R50%
1	45	3	10,40	1225,32	1,10	5,08
2	50	5	75,50	792,97	1,00	3,70
3	50	5	19,20	2250,39	1,04	4,75
4	45	5	98,50	683,64	1,06	3,42
5	50	5	58,15	1042,69	1,02	3,86

Optimization of the dose for PTV and dose to critical organs was done according to the standards of the Stereotactic Ablative Body Radiation Therapy (SABR) UK Consortium report (Version 6.1, January 2019). For the liver, both Mandatory and Optimal criteria were met for four cases.

For the first three cases, the volume of GTV was estimated by CT in the following respiratory phases: 0%, 25%, 75%, 100%, 75%, 50% and 25%. In addition, MIP (Maximum Intensity Projection) reconstructions were performed. The obtained GTV volumes were compared to the GTV volumes for CT DIBH. The change in volume for three cases was:

Patient	$V\_GTV_{free}\ [cm^3]$	$V\_GTV_{DIBH}[cm^3]$
1	3,00	0,50
2	44,50	30,40
3	4,16	1,21

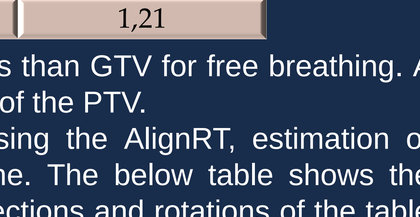
GTV volume obtained for DIBH CT is definitely less than GTV for free breathing. A margin of 5-6 mm was added to obtain the volume of the PTV.

For evaluation of precision patient positioning using the AlignRT, estimation of patient's movement with using kVCBCT was done. The below table shows the average values of shifts for all fractions and all directions and rotations of the table after checking the patient's position using CBCT. Table position corrections after CBCT were performed using HexaPod system. CBCT was used with ClipBox option.

Patient	Sup+ [cm]	Right+ [cm]	Ant+ [cm]	Cor [degree]	Sag [degree]	Trans [degree]
1	0,67	0,27	0,07	0,00	0,00	0,00
2	0,12	-0,02	-0,10	-0,78	-1,20	-0,34
3	-0,57	0,00	0,43	-0,07	0,47	-0,83
4	0,16	-0,16	-0,22	-0,1	0,18	0,22
5	0,18	-0,16	-0,62	0,92	-0,16	1,68

The average shifts for each direction did not exceed 7 mm. The rotations for each axis did not exceed 1.5 degrees.

Treatment tolerances for SBRT radiotherapy in the AlignRT system							
Direction	VRT [cm]	LNG [cm]	LAT [cm]	MAG [cm]	YAW°	ROLL °	PITCH°
Values	-0,3 ± 0,3	-0,3 ± 0,3	-0,3 ± 0,3	0,3	-0,3 do 0,3	-0,3 do 0,3	-0,3 do 0,3



CBCT patient with liver cancer irradiated with SBRT DIBH

Remarks for application of SBRT DIBH technique in liver irradiation:

- reducing the volume of GTV and sparing more healthy tissue liver volume,
- less liver toxicity is expected for lower GTV volume (dose to liver-GTV Dose is ≥700cc < 15Gy),
- verification of patient positioning by CBCT after applying the AlignRT surface control showed negligible shifts and rotations.

CONCLUSIONS

Thanks to the use of AlignRT, the position of the patient from the day of the CT for treatment planning was recreated with much better precision. Despite moving and difficult to reproduce targets, the volume of GTV was significantly reduced. Due to the use of the SBRT DIBH technique, the healthy part of the liver is spared and allowing for to reduction of the irradiated volume of healthy tissues.