BREAST AND CHEST WALL TREATMENT WITH PENCIL BEAM SCANNING AT THE PROTON THERAPY CENTRE IN PRAGUE

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The Proton Therapy Centre in Prague (PTC) is a leading global health care facility and one of the most advanced proton therapy providers in Europe.

The centre is prepared to provide treatment for 2500 patients a year, with 4 treatment rooms equipped with state-of-the-art active scanning techniques.

The clinical team under the leadership of Vladimír Vondráček, MSc, Head of Medical Physics, has developed a comprehensive program to treat patients suffering from breast cancer.

> *PBS proton irradiation in the breast area is often the only option to deliver the prescribed treatment dose to the treatment volume, while avoiding excessive dose to the surrounding normal tissues.*
>
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Proton therapy using the pencil beam scanning (PBS) technique to treat breast cancer, lymphoma and target volumes close to the liver, enables homogenous coverage of the target volumes while maximizing the probability of sparing the surrounding organs-at-risk, such as the heart, contralateral breast, both lungs, liver, etc.

It is necessary, as for other dynamic irradiation techniques, to suppress the influence of breathing and the heart beating interplay effect on the final dose distribution. Proton therapy using PBS also requires precision in patient's setup. Meeting these requirements enables the utilization of clinical treatment plans in a safe and accurate way.

Clinicians of PTC have developed a comprehensive program to treat patients suffering from breast cancer. 25 patients with breast cancer were treated by PBS from April 2015 to June 2017.

The workflow can be described as follows:

Patient Setup

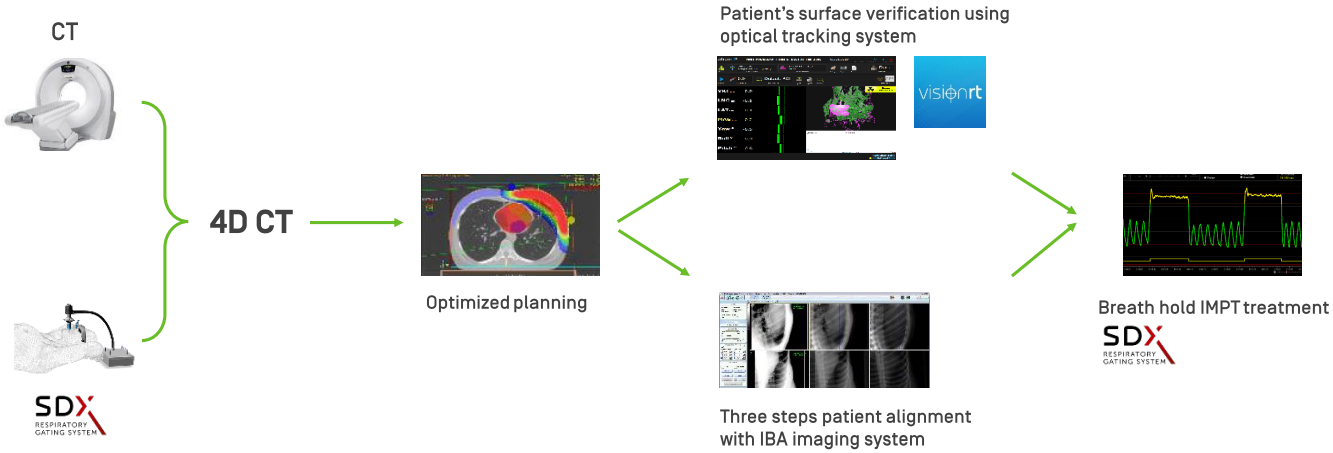
A two-step patient setup protocol was used. Both steps are performed during deep inspiration breath hold using a Dyn´R spirometer. In the first step, bone-structures near the target volume are outlined on the acquired x-ray images and digitally reconstructed radiograms (DRRs) in all directions (rotation and translation) to enable registration and matching. It is necessary to observe the position of the shoulder-joint as this has proven important to manage breast shape and position. In the second step, X-ray contrast post-operation markers in combination with breast surface position is used. The surface position is matched with the patient reference surface using two infrared stereoscopic cameras (Vision RT system). The reference surface is exported directly from the treatment planning system.

In the case of good agreement between the position of the markers and the surface position, only minor corrections need to be applied. Translations of up to 7 mm are allowed in the second step. When the position of the markers are shifted beyond the limit, patient positioning has to be redone.

Planning

Elekta's Xi0 version 4.80.03 treatment planning system was used.

A treatment plan consists of one direct field in the case of small non-arched breasts. A two-field irradiation technique was used for the bigger more arched breasts. These two fields should avoid the



Workflow for breast cancer treatment

tangential impact of the proton beam. The first beam has a gantry angle of 0° or something very close to this angle. The second field is orthogonal to the first field or slightly inclined to the first field. The dose has been reduced to approximately 90% of the prescribed dose in the subcutaneous tissue. The QA plans were calculated for these treatments and the robustness was evaluated with a 5 mm field shift in every direction.

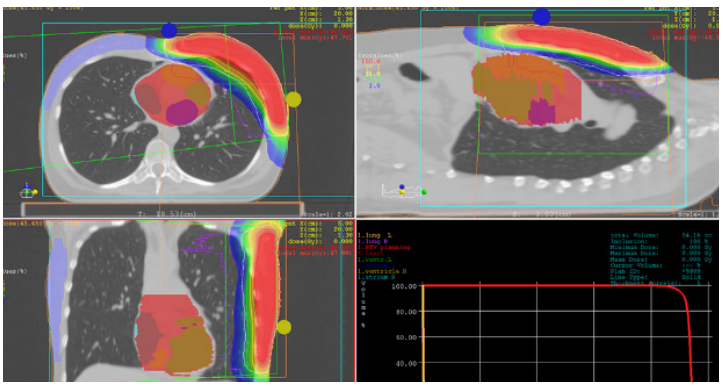
Treatment

It was found that observing the described workflow results with homogeneous irradiation of the whole breast, including affected supraclavicular lymph nodes.

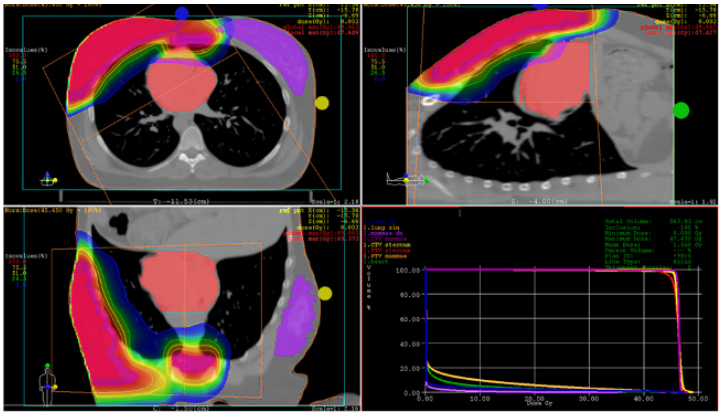
Treatment plan evaluation shows that in the case of full PTV coverage, the mean dose to the heart was only 0,3 CGE, to the ipsilateral lung 3,05 CGE, and contralateral lung only 0,16 CGE. Furthermore, evaluation of QA plans shows sufficient robustness with field-shifts of up to 5 mm causing no clinically significant deviation in the optimal dose distribution.

Conclusion

PBS proton irradiation in the breast area is often the only option to deliver the prescribed treatment dose to the treatment volume, while avoiding excessive dose to the surrounding normal tissues. Respiratory gating and precise daily positioning during every treatment session, as well as post-surgery marker setup correction are necessary requirements of the treatment.



Xi0 treatment plan of a breast tumor treated at PTC



Xi0 treatment plan of a chest wall treated at PTC

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