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Needle-based stepping source electronic brachytherapy – a feasibility study

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Objective

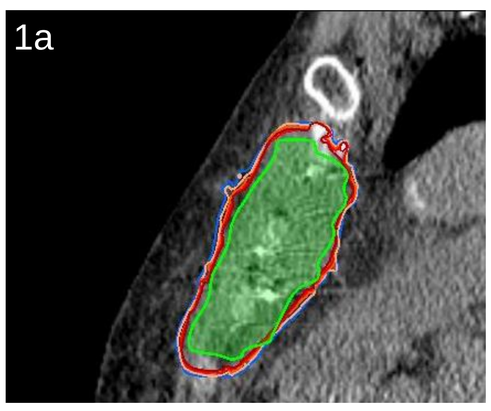
Electronic needle-based kilovolt brachytherapy (eBT) may resemble an economic alternative to multi-catheter (HDR) and permanent seed implantation (PSI) brachytherapy. Currently, needle-based eBT is used for IORT during kyphoplasty and has been studied in brain tumors[1, 2]. To further investigate its applications, we have evaluated wether interstitial tumors treated with ^{125}I seeds in a palliative setting would have been suitable for treatment with needle-based eBT.

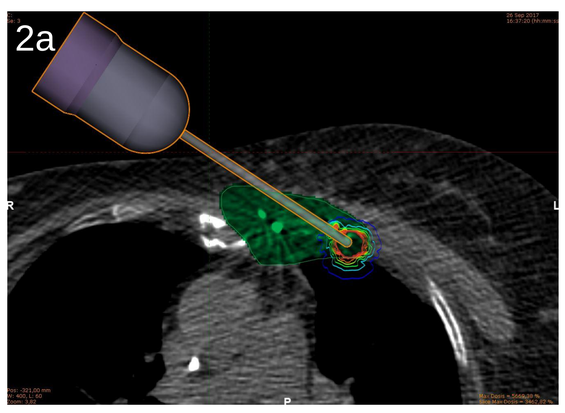
Methods

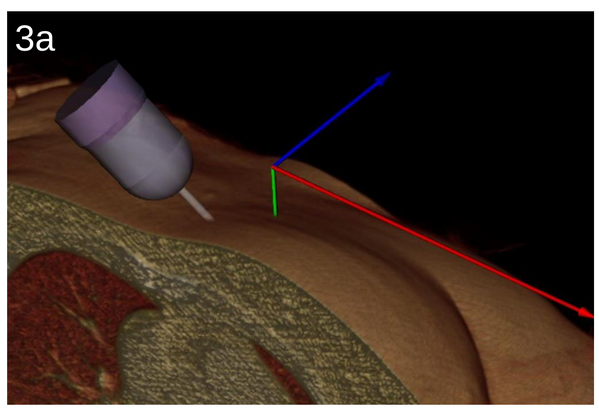
Post-interventional CT studies of 5 patients who had received PSI with ^{125}I seeds in tumors were used as templates for planning.
Four patients had been treated at the tumor site with PSI only and 1 patient had received a partial tumor boost by PSI after EBRT.
PTV_{eBT} was defined as either the PTV of PSI or, in case of the partial tumor boost, the 100% isodose line of PSI. The same dose as prescribed in PSI was used for eBT. We then simulated treatment with a needle applicator (length=94mm) of a kilovoltage x-ray system (INTRABEAM, Carl Zeiss Meditec AG, Germany) using a dwell point stepping (DPS) approach. For planning the dwell points an algorithm for kV-dose distribution in tissue of various densities was used (Radiance, GMV Innovating Solutions S.L., Spain). For dose summation Radiance dosimetry files were transformed and imported into Velocity (Varian Medical Systems Inc., USA) for forward planning. DPS dose distributions achieved with eBT were then compared to those achieved with PSI.

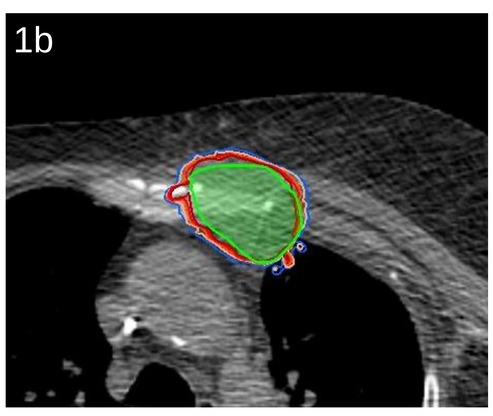
Results

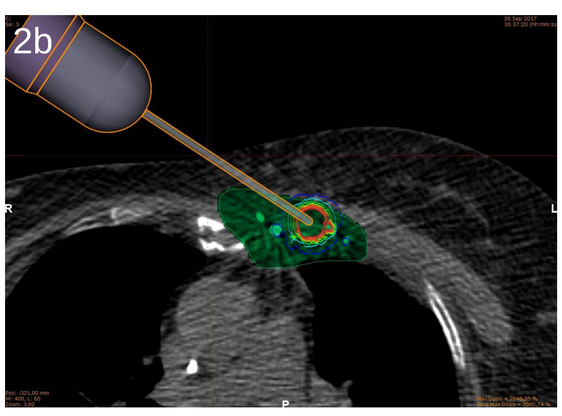
The total number of dwell points for eBT per patient ranged from 2 to 20, while 1 to 7 trajectories per patient were required. Prescribed doses (PD) ranged from 20 to 50 Gy. Mean deviation of $D90_{eBT}$ from PD was ±2,3 Gy. In 2 patients $D90_{eBT}$ was lower than PD, but remained higher than the D90 obtained with PSI. The conformation number (CN) was calculated for every plan and ranged between 0,63 and 0,89 (mean: 0,71 ± 0,09)[3].

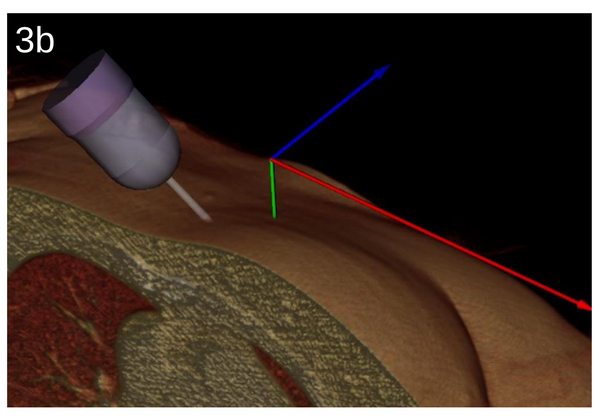












1a/1b: CT-study in sagital/axial plane with PTV_{eBT} (green) and surrounding isodose lines, aquired by DPS and dose summation.
2a/2b: Dwell point steps with a simulated needle applicator including dose distribution in PTV_{eBT} (green).
3a/3b: 3D-reconstruction of the CT-study including the simulated needle applicator changing positions along the trajectory.

Conclusion

Needle-based eBT with a DPS approach was dosimetrically feasible for the interstitial irradiation of tumors that had originally been treated with PSI. This warrants the need for a puncture technique and automated inverse planning for further evaluation of needle-based eBT as a treatment option.

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