

# EPID-Based In-Vivo Dosimetry With LAP RadCalc Software: A User Experience

In-vivo dosimetry (IVD) is the measurement of the dose delivered to the patient during a radiotherapy fraction. It is a final step of the dosimetric quality assurance process and provides a quantitative metric to score the treatment accuracy.

In the Radiotherapy Center at the Santa Maria Annunziata Hospital in Florence, Italy, which is directed by Dr. Silvia Scozzianti, we use our two Elekta Versa HD linacs to treat about 1,000 patients per year. We use the Monaco treatment planning system to perform volumetric modulated arc therapy (VMAT) treatments, with about 30 percent of patients receiving stereotactic body radiation therapy (SBRT) or stereotactic radiosurgery (SRS). Our main aim is to ensure quality assurance in all the treatment steps, given the high complexity of this kind of treatment.



Figure 1. From left to right: Silvia Bettarini, Serenella Russo, Claudia Poggiali, and Andrea Bruschi. Serenella Russo is the senior medical physicist responsible for the radiotherapy activities at the Santa Maria Annunziata Hospital in Florence, Italy.

We have chosen the quality assurance software RadCalc to perform IVD because it allows 3D dose reconstruction of transit and through-air EPID images on the planning CT dataset. Acquired in-vivo images are transmitted back through the patient to determine the incident fluence, differentiating it from all other available solutions.

We use the RadCalc Collapsed Cone Convolution Superposition module for the following routines: the secondary independent dose calculation, the EPID-based pre-treatment QA, the EPID-based IVD, and the log files-based 3D dose reconstruction. It also features an optimized deconvolution kernel for dealing with tissue inhomogeneity.

RadCalc is used daily in our clinic to verify the dose delivered to the patient and to provide adaptive radiotherapy driven by IVD. Our workflow involves the IVD acquisition and analysis for all sessions of SBRT treatments, partial breast irradiation, and fast and forward breast irradiation. Hypofractionated breast cancer and head and neck cancer treatment schedules involve IVD for the first three sessions, followed by a weekly check using IVD for the remainder of the treatment (ranging from 15 days for breast up to 33 days for head and neck). Lung cancer and other prescriptions that involve more than ten sessions follow the same schedule. Trimodality therapy for bladder cancer involves IVD for all treatment sessions. Pelvic region treatments (such as prostate, uterus, whole pelvis, etc.) do not have a default schedule: IVD is performed every time cone beam CT is not perfectly compliant according to OARs, organ filling, or patient belly surface.

RadCalc allows applying different gamma calculation defaults and acceptance criteria based on user-defined rules for DVH and isodoses. We usually perform a dose and gamma passing rate comparison between the TPS planned dose and the daily IVD dose for targets and organs-at-risk (OARs) according to the different treatment sites.

This routine was first implemented for the head and neck region to detect re-planning needs due to patient's weight loss or tumour shrinking during the treatment period. An example is reported in Figures 2 and 3, showing IVD dose distributions and DVH acquired on two different days, the first one at the start of the treatment and the second one halfway through the treatment course.

Afterward, we started to extend IVD to all patients, with the help of RadCalcAIR (Automated Import and Report), a routine that provides a fully automated process for plan import, computation, and 3D dose analysis. This way, we are not only able to detect positioning or delivery issues but also additional error sources, such as OAR filling in pelvic region treatments.

One excellent example of RadCalc's performance we observed in our clinic is related to delivery errors: the presence of the linac couch junction bar in the radiation field during the treatment. The ability to detect this kind of issue with IVD allowed us to adjust the patient positioning on the couch for the following radiotherapy sessions, providing the right quality assurance from the start to the end of the process.

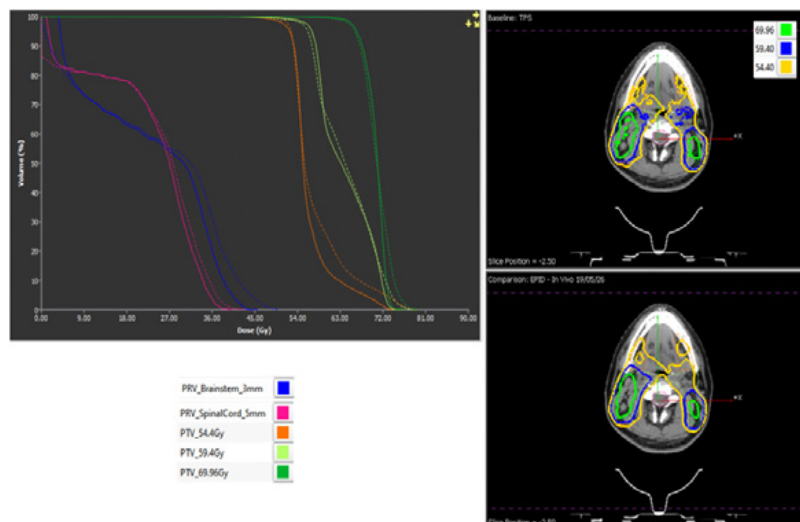


Figure 2. IVD acquired at the start of the treatment for a patient suffering from head and neck cancer. A comparison of the DVHs and dose distributions is displayed. The DVH solid lines represent planned doses, while dashed lines represent IVD doses. They are in very good agreement within 5 percent.

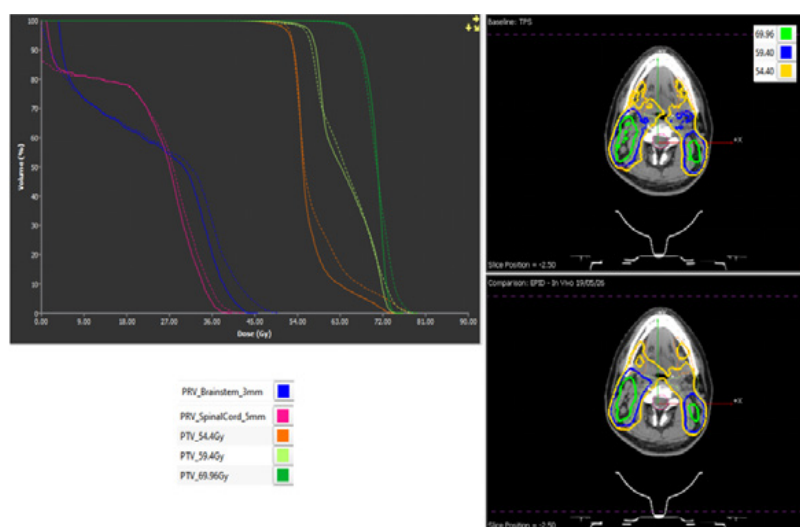
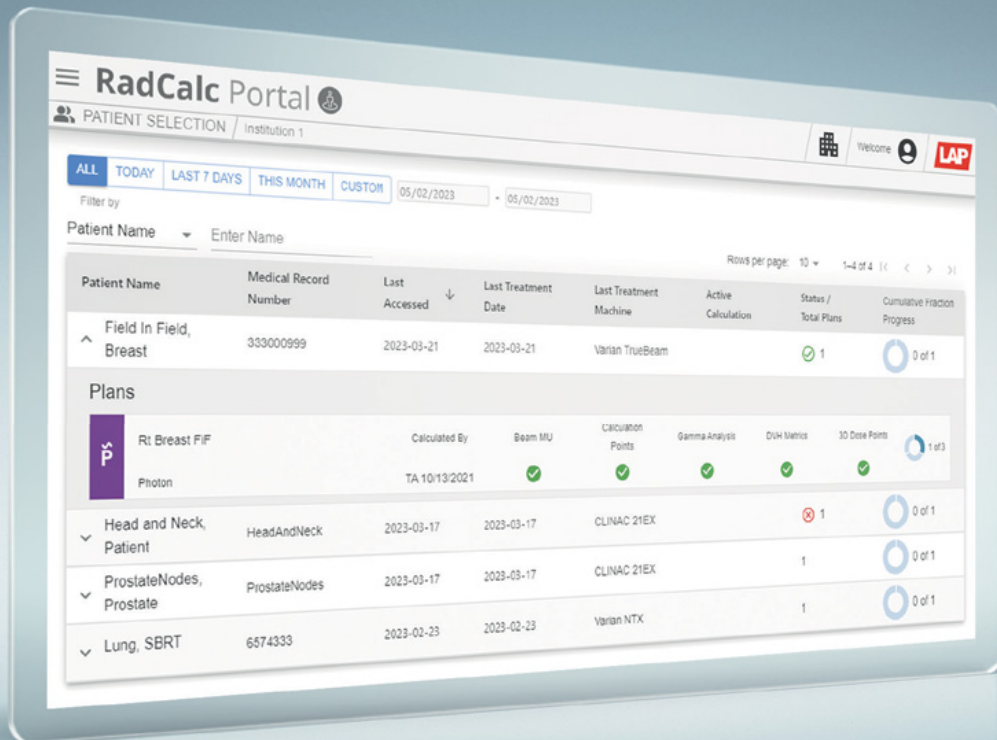


Figure 3. IVD acquired halfway through the treatment for the same patient as Figure 1. In this case, a dose difference of more than 5 percent is shown between planned and IVD doses for targets and reference OARs. CBCTs, in fact, showed significant patient weight loss, in perfect agreement with IVD. The patient replanning on a new CT scan was scheduled after that, ensuring adaptive RT with perfect timing.



**Claudia Poggiali** is a junior medical physicist at the Santa Maria Annunziata Hospital in Florence, Italy. She graduated in high energy physics at University of Florence and then attended the Medical Physics residency.



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