Development and optimization of a dedicated system for hyperthermia treatment of patients with superficial/semi-depth tumours

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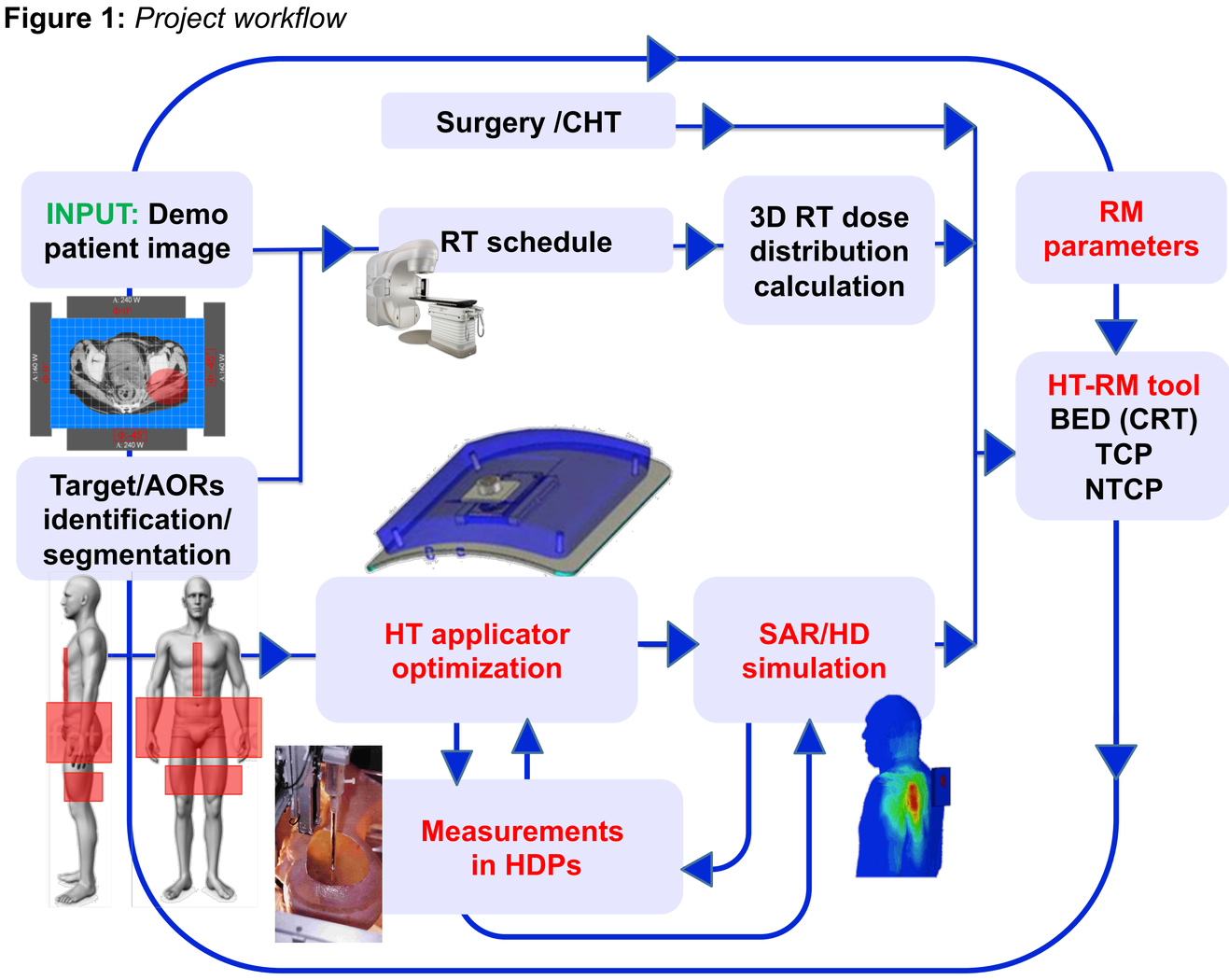
Hyperthermia (HT) is a cancer treatment used in combination with chemo/radiotherapy (CHT/RT), exploiting elevated temperatures to kill cancer cells sparing organs at risk (OARs). Clinical studies on a variety of tumour types suggested synergistic effects of HT combined with CHT, RT, or their combination (CRT). Unfortunately while it has been shown that the **heat distribution (HD) and the temperature-time-history are fundamental for a positive outcome of the treatmen**t, the HD generated by commercial applicators in operating conditions could be very different than expected, probably due to heterogeneous tumour sites and shape, potentially contributing in explaining the variety of clinical trial outcomes. Thus, even if HT is a promising clinical choice, some problems still remain to be addressed.

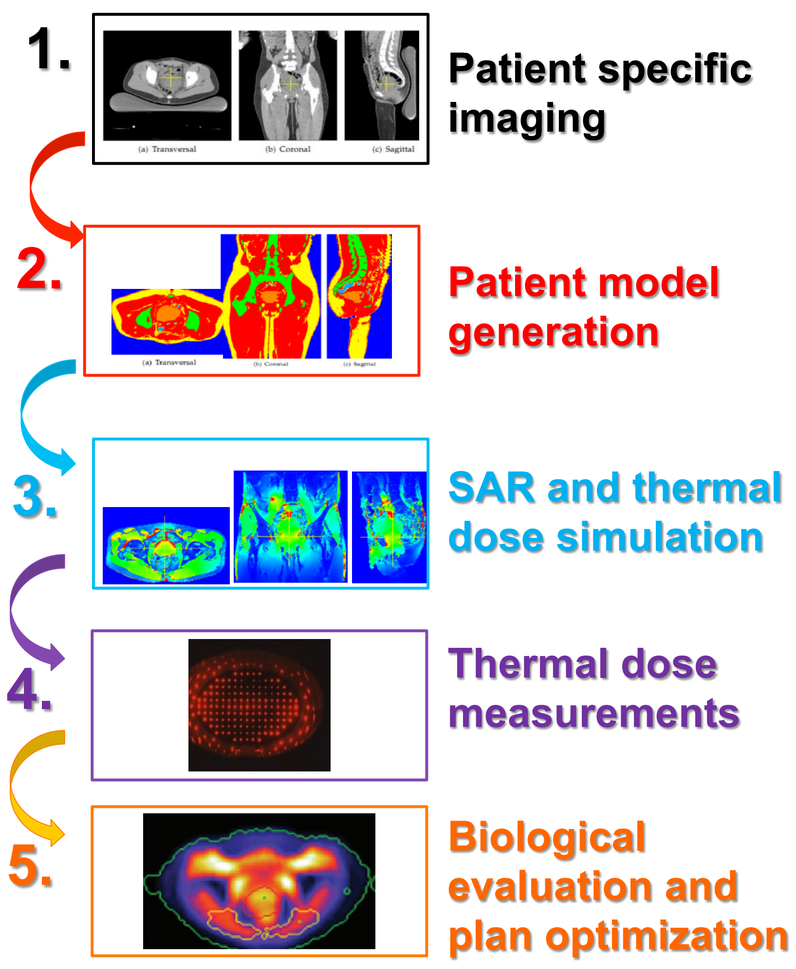
Major issues are the lack of: specifically dedicated devices for semi-deep tumour; accurate provisional tools for HD, patient-like phantoms; measurement devices for real time monitoring; quality assurance and tools for predicting the expected biologically effective dose (BED), tumour control probability (TCP) and normal tissue complication probability (NTCP) by using radiobiological models (RMs) and their parameters (e.g. α, β) accounting for the effects of different modalities on organs and tissues also including tumour cells. These drawbacks can be overcome by the implementation of a novel system to deliver HT in superficial/semi-deep tumours, together with experimentally validated numerical simulations and **novel treatment planning systems** for predicting the effect of combined treatment strategies.

Figure 1: *Project workflow*



Our ongoing research is focused on the development of a novel combined applicators based on existing antennas able to deliver accurate heat distribution (HD) for superficial/semi-deep seated tumours and demonstrate the clinical feasibility of an improved HT system using radiobiological models (HT-RM tool).

Figure 2: *Treatment planning system*



We will adopt a **novel delivery strategy** to overcome actual technical limitations thus exploring the penetration efficacy of heat when fully innovative combined units are applied in clinical set-ups (Figure 1). To improve planning and delivery, we are developing a **dedicated tool (software) based on radiobiological models to be integrated in the clinical option of HT treatments** (Figure 2). Combined applicators focusing the electromagnetic energy in the semi-deep target tumours up to 5 cm mainly located in abdominal regions such as high-grade soft tissue retroperitoneal or thigh sarcoma, locally advanced kidney, pancreas carcinoma and liver metastasis are not yet available. The development, validation and introduction of novel designed arrays based on the Gantt scheme of Figure 3 could be beneficial for patients in term of heat distribution and treatment successful. This research is conducted in collaboration with industrial partner (Med Logix S.r.l.) funded by Regione Lazio.

Figure 3: *Project Gantt*

Years	1												2												3	
Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Project starting (User requirements specification and start up)																										
Phase I: Simulation and measurament for novel combined applicator																										
Phase II: Design and development of novel device for semi-deep HT																										
Phase III: Calculation, simulation and data analysis for HT-RM tool																										
Report preparation and data publication																										