SUPERFICIAL AND SEMIDEEP
434 MHZ RADIATIVE HYPERThERMIA
HYPERTHERMIA RADIO-BIOLOGICAL RATIONALE

Hyperthermia (HT), heating tumors in the range 41-43°C, is a powerful radio and chemosensitizer. The effectiveness of HT as well as its safety, in combination with radiotherapy and chemotherapy, has already been proven in phase III clinical trials [1,3], particularly in patients with very large or very advanced stages of cancer and recurrent tumors. HT enhances the effect of radiotherapy on the tumor, without additional toxicity for healthy tissues, by means of three synergistic mechanisms:

1. **Inhibition of DNA damage repair**: HT enhances the effectiveness of radiotherapy by inhibiting repair of DNA damage [2,4,5,6].
2. **Direct cell killing**: HT selectively kills radioresistant hypoxic tumor cells [2].
3. **Reoxygenation**: HT increases tissue perfusion resulting in reoxygenation, thereby reducing hypoxia and increasing radiosensitivity [2,5,7].

With regards to chemotherapy, hyperthermia targets its action within the heated tumor region without affecting systemic toxicity [8]. It has also been shown that local hyperthermia has the capability of inducing systemic anti-tumor immune responses [1].

HYPERTHERMIA CLINICAL EVIDENCE

Several phase III randomized clinical studies have already shown the benefits of adding hyperthermia to standard therapies (chemo-radiotherapy). Response rates, local control and overall survival are often 1.5 times higher than with radiotherapy or chemotherapy alone, without inducing additional side effects [1,3].

ALBA ON 4000D CLINICAL INDICATIONS

ALBA ON 4000D is certified to treat:
- Head and Neck tumors
- Breast tumors
- Melanoma
- Soft tissue sarcoma
- Chest wall recurrences
- Cutaneous lymphoma
**ALBA ON 4000D TECHNOLOGY**

The ALBA ON 4000D is a radiative hyperthermia system working at a fixed frequency of 434MHz. The unit is equipped with radiative technology curved microstrip applicators with an integrated water bolus to safely and effectively heat targets, in the range of 41-43°C, for 60 minutes, as required by the ESHO (European Society for Hyperthermic Oncology) guidelines (9).

**EFFECTIVE POWER DEPOSITION**

The multiple radiative microstrip applicators of ALBA ON 4000D are curved at a fixed radius and are perfectly tuned at 434MHz. The high efficiency and homogeneity (no hot-spots) allow hyperthermia treatments at a depth of up to 40 mm ± 5 mm as demonstrated both in phantoms (10,11) and in patients (12,13).

The curved ALBA ON 4000D applicators are designed to adapt to the curved anatomy of the patient.

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**ALFA**  
66 cm²

**BETA**  
96 cm²

**GAMMA**  
216 cm²

**DELTA**  
440 cm²
RADIATIVE VS CAPACITIVE

ALBA Radiative curved applicators guarantee a very favorable SAR (Specific Absorption Rate) both on muscle and heterogeneous tissue targets and a very low power density in fat tissue. This uniqueness results in more favorable SAR and temperature distribution for superficial tumor locations, compared to Capacitive Electro-Hyperthermia electrodes characterized by a power absorption in the poorly perfused fat tissue much higher than in muscle tissue, which produces lower target temperatures with the risk of overheating heterogeneous normal tissue (14).

POSITIONING SOLUTIONS

ALBA ON 4000D is supplied with specific tools which display the EFS (Effective Field Size) in 2D and the E-Field direction of each applicator. These tools allow both a correct selection of the best applicator with respect to the lesion geometry and the perfect alignment of the max SAR of the applicator with the central axis of the lesion.

Results - Applicators on Phatom 3

Heating with a capacitive system yields the maximum SAR in the fat layer, whereas the radiative CFMA has its maximum in muscle tissue.

As an option ALBA ON 4000D can be connected to an external ultrasound scanner useful also to position applicator and temperature sensors on the target.
**DOSIMETRY**

An embedded multichannel thermometer detects real-time temperature readings in up to 32 sensors positioned on the patient skin or in the target volumes. Totally immune to radiofrequency interference, the ALBA ON 4000D thermometer guarantees very fast detection of the temperature sensors at the remarkable precision of ±0.2°C.

Temperature readings recorded throughout the treatment are stored in the database for post-processing data analysis.

The pre-treatment picture of the target area with the points of interest where temperature sensors have been positioned is downloaded onto the ALBA ON 4000D Treatment SW to show in real-time the temperature reached on the specific target.

**ERGONOMY**

ALBA ON 4000D is user-friendly, intuitive and easy to install in any outpatient room. It is mounted on wheels which allow the operator to move the unit according to the need. The mechanic structure and its ergonomy makes it easier for the operator to interact with the patient for the treatment of different anatomic sites.

The modular ALBA ON 4000D platform allows for the simultaneous use of two applicators, also of different sizes if necessary, on the same patient to treat larger lesions on a chest wall recurrence.

A single external PC console synchronizes the use of two ALBA ON 4000D systems treating different locations on a patient with an independent control of power and water temperature for each applicator/lesion.

Alfa applicator on a head and neck lesion.  
Beta applicator on a supraclavicular lesion.  
Gamma applicator on a chest wall recurrence.
An example of a 3D temperature simulation of Plan2Heat based on a patient specific 3D CT Scan image and a 3D ALBA Applicator SAR simulation.

ALBA ON 4000D can be provided with a hyperthermia treatment planning software PLAN2HEAT in continuous development in collaboration with Amsterdam UMC (Amsterdam University Medical Center). The goal is to find the optimal setting to maximize the power deposition in the target area while preserving the surrounding healthy tissue. PLAN2HEAT is able to calculate the power absorption, the consequent temperature distribution and the optimized setting in a 3D patient-specific anatomy model generated from patient CT/MRI images.

CT scan of patient target

Dielectric tissue type property assignment according to automatic Hounsfield unit recognition

Temperature simulation performed by Plan2Heat

QUALITY ASSURANCE

Temperature accuracy and efficient SAR deposition are key elements to be controlled during the lifetime of the ALBA ON 4000D. Quality assessment, according to ESHO guidelines (15), can be performed using a specific kit to calibrate all temperature sensors and a dedicated anatomic phantom (muscle type) for ALBA applicator 3D SAR evaluation.

TPS

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ALBA DATA MANAGEMENT SYSTEM

The ALBA ON 4000D Data Management System offers an integrated data management solution which allows to import patient data as DICOM Worklist and export treatment reports in PDF to Hospital Information System (HIS). Treatment of raw-data is stored in standard xml files. This allows for post-processing and simplifies data sharing which is useful for data analysis within clinical trials.

INTEGRATION WITH RADIOTHERAPY PACS SYSTEM

The ALBA ON 4000D software is designed to be fully integrated with the radiotherapy PACS systems in order to introduce hyperthermia more easily into the radiotherapy workflow from treatment planning to the treatment itself.
BIBLIOGRAPHY


