CLINICAL APPLICATION OF INTRALUMINAL HOT WATER BALLOONS COMBINED WITH LOCOREGIONAL HYPERTHERMIA FOR TREATMENT OF OESOPHAGEAL TUMOURS

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Purpose: To improve hyperthermia (HT) for oesophageal tumours with an intraluminal Hot Water Balloon (HWB) in combination with the standard AMC-4 waveguide system.

Methods: Five patients with an oesophageal tumour, median length 6 cm, were treated with neo-adjuvant chemoradiation combined with weekly HT for 5 weeks. HT was given using the locoregional 70MHz AMC-4 waveguide system, with an additional thermal boost using an intraluminal HWB. Balloons were 1 cm in diameter and 6 cm in length, and were placed at tumour position under endoscopic guidance prior to each HT session. Water of 51-52°C was circulated through 3-lumen tubing by a rollerpump at a flow rate of 30 ml/min, resulting in a HWB temperature of ~43°C. Duration of HWB application was increased from 2×5 min during the steady state (SST) period of session I, to 15, 30, 45 and 60 min during session II, III, IV and V, respectively. Tumour temperature profiles were measured intraluminally using multisensor thermocouple probes mounted on the outside of the HWB, and expressed in terms of maximal (T_{10}^{lumen}) and minimal (T_{90}^{lumen}) luminal tumour temperature and the heterogeneity coefficient $HC = \left(T_{10}^{lumen} - T_{90}^{lumen}\right) / \left(T_{90}^{lumen} - 37°C\right)$. Thermal dose was expressed as cumulative equivalent minutes with T_{90}^{lumen} at 43°C ($CEM\ T_{90}^{lumen} @ 43°C$) per session.

Results: For all treatment sessions of all patients T_{90}^{lumen} significantly increased, on average from 38.6 ± 0.2 °C (mean ± SEM) before HWB application to 42.1 ± 0.1 °C during HWB application, i.e. an increase of 3.5 ± 0.1 °C. By increasing HWB duration from 9.2 ± 1.6 min (2×5 min) to 57.9 ± 1.2 min (60 min), thermal dose increased from 9.2 ± 4.5 to 22.3 ± 4.1 $CEM\ T_{90}^{lumen} @ 43°C$. Temperature profiles along the tumour were more uniform during HWB application, as indicated by a significant decrease in HC from 0.48 ± 0.04 to 0.29 ± 0.03.

Session	Time HWB		SST before HWB		SST during HWB		Total SST period
	aim [min]	actual [min]	T_{90}^{lumen} [°C]	HC	T_{90}^{lumen} [°C]	HC	CEM T_{90}^{lumen} @43 °C
I	2 × 5	9.2 ± 1.6	38.9 ± 0.4	0.48 ± 0.21	42.2 ± 0.6 **	0.33 ± 0.09	9.2 ± 4.5
II	15	16.8 ± 0.7	39.0 ± 0.5	0.35 ± 0.11	42.5 ± 0.7 **	0.27 ± 0.11	20.8 ± 7.2
III	30	26.8 ± 4.3	38.3 ± 0.5	0.58 ± 0.14	42.0 ± 0.3 **	0.21 ± 0.04 *	14.2 ± 5.1
IV	45	45.1 ± 0.7	38.6 ± 0.4	0.44 ± 0.11	41.9 ± 0.2 **	0.36 ± 0.06	18.2 ± 5.3
V	60	57.9 ± 1.2	38.2 ± 0.2	0.53 ± 0.04	41.7 ± 0.2 **	0.28 ± 0.04 *	22.3 ± 4.1
mean	-	-	**38.6 ± 0.2**	**0.48 ± 0.04**	**42.1 ± 0.1 ****	**0.29 ± 0.03 ***	-

*p<0.05 vs. before HWB; **p<0.01 vs. before HWB (determined by paired t-tests).

Conclusion: Hot Water Balloons are clinically feasible, simple and safe devices, which can be easily combined with locoregional hyperthermia to achieve an additional temperature rise in the vicinity of the HWB.

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