Cytoreductive surgical treatment of pleural mesothelioma: a comparison study betweem Radiofrequency Ablation and MRgFUS treatments in a swine model of mesothelioma

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Purpose: Malignant pleural mesothelioma (MPM) a rare type of tumor, associated with the exposure to asbestos that carries poor prognosis, with a life expectancy generally less than one year after diagnosis [1]. For most countries the peak in mesothelioma cases is predicted to take place in the period between 2010 and 2020 [1,2]. The objective of this study was to determine and to compare the feasibility of mesothelioma debulking with Magnetic Resonance guided Focused Ultrasound Surgery (MRgFUS) and Radiofrequency Ablation (RFA) in a porcine model of mesothelioma.

Methods: For this study 13 Yorkshire female pigs (~25 lbs) were used. Animals were immunosuppressed with cyclosporine (Gengraf Oral Solution, MA). Tumor model was developed using a human mesothelioma cell line, MSTO-211H (ATCT), injected in the pleural space in the right lower hemithorax, under fluoroscopy guidance (Siemens, Arcadis, PA). Animals were imaged using MRI at baseline and followed-up every 4 weeks post-inoculation (1.5T scanner, Avanto, Siemens Healthcare, PA). A body array coil and a spine array coil (Siemens, PA) were simultaneously used. Five animals were treated at the end with percutaneous RFA. A RF-3000 Radio Frequency Generator (Boston Scientific, MA) and a 2.0 cm diameter and 15.0 cm length LeVeen needle (Boston Scientific, MA) with an 'umbrella' configuration were used. The RFA treatment was guided under fluoroscopy imaging (Siemens Arcadis). Four animals were treated with MRgFUS at the local Focused Ultrasound Center, using the ExAblate 2000-OR system (Insightec, Israel) and a 3T MR scanner (GE).

Results: Pleural effusion developed in all animals shortly after cell inoculation. Pleural thickening, pleural-lung adhesions and diaphragm thickening were observed in all animals. The power applied in the RFA treatments varied from 0.1 Ws^{-1} and 4.82 Ws^{-1}. Ablation areas treated with RFA had a circular shape and their diameters ranged between 2 and 4 cm (figure 1). For the treatment with MRgFUS, we used different numbers of focal spots depending on the size of the tumor and power to be delivered. The number of spots varied between three and seven and total power varied from 1912 W to 4592 W. Necropsy confirmed that the depth of the lesion increased with the increasing of total power (figure 2) and some skin burns were observed at the highest powers.

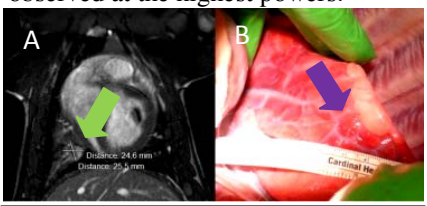

Figure 1 – RFA treatment of pig #6. A: Post-ablation MRI - ablated area in the right side (green arrow); B: Necropsy image, resultant ablated area (purple arrow).

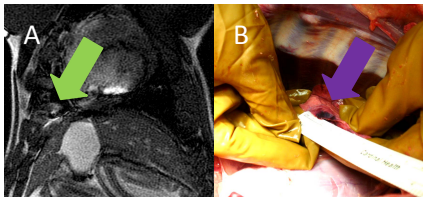

Figure 2 – MRgFUS treatment of pig #12. A: Post-ablation MRI, ablated area near the diaphragm (green arrow); B: Necropsy image, resultant ablated area (purple arrow).

Animal	Treatment	Ablation Size (cm^2)
3	RFA	2.3x1.7 2.6x1.6
4	RFA	1.9x1.9 2x2
6	RFA	2x2 1.4x1.2
7	RFA	1.5x2.5 1.3x2.7 4x4
8	MRgFUS	1.5x1.3
9	RFA	2.3x2.3 3x3
10	MRgFUS	1.4x1.4
12	MRgFUS	2.4x2.6
13	MRgFUS	4.2x2.5

Table 1 – Ablation size results, comparing both treatments. Pigs #12 and #13 were treated with higher powers of MRgFUS, resulting in larger ablated areas.

Conclusions: This study was an innovative project in both tumor characterization and treatment of MPM. It enabled to successfully develop a tumor model in large animals using a human mesothelioma cell line. To our knowledge this is the first time that a treatment comparison between RFA and MRgFUS was done for this type of disease. We were able to prove the feasibility of both techniques and we obtained ablations areas with approximately the same size. MRgFUS had the advantage of not requiring incisions and being less invasive, but RFA could treat larger areas faster.

References: *[1] Tsao, N.S., et al., Malignant Plueral Mesothelioma. Journal of Clinical Oncology, 2009. 27(12): p. 10. [2] Campbell, N.P. and H.L. Kindler, Update on malignant pleural mesothelioma. Semin Respir Crit Care Med, 2011.* ***32****(1): p. 102-10.*

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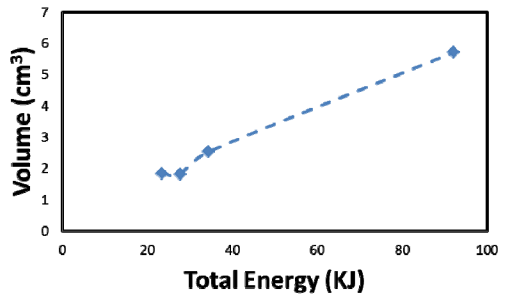

Graphic 1 – Resultant ablated volumes in MRgFUS mesothelioma treatments