Transesophageal HIFU probe to treat ventricular arrhythmias: characterization and preliminary experiments

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Catheter ablation is the gold standard to treat focal ventricular tachycardia. However, this method remains invasive and has a high recurrence rate. As it could induce thermal lesions at distance and throughout myocardium thickness, high-intensity focused ultrasound was considered as an alternative therapy. Based on numerical simulations, a transesophageal HIFU probe guided by ultrasound was designed. This study aims at characterizing the transducer acoustic performance and validating the probe ability to produce transmural lesions.

The transesophageal HIFU probe is composed of a plane 3-MHz piezocomposite transducer cut into 32 rings truncated at 13.8 mm. An unused cross-shape zone is included in the annular array for the imaging part. The probe is driven by a Vantage Verasonics system. Pressure fields are visualized using two methods: a novel method to image focused ultrasound fields in real time, and the hydrophone measurements. Results are compared to pressure field simulation computed with Rayleigh integral method. Acoustic radiation force measurements are performed with a balance and a brush target to determine acoustic intensity and electro-acoustic performance. *Ex-vivo* experiments are carried out on swine myocardium slices: two right ventricles, two left ventricles and one septum. Sonication is performed at an acoustic power of 86W at the surface of the transducer, during a variable duration with a duty cycle of 50%. The focus is between 82 and 106 mm.

Imaged and measured pressure fields agreed with simulation. HIFU beam can be focused at a distance between 20 and 100 mm. The probe can reach an acoustic intensity of 14.04 W/cm2 and an electro-acoustic performance of 60%. On 21 shots, 100% induce lesions and 52% are transmural. Depending on myocardium type and thickness, ensuring transmurality at 80-to-110-mm focus depth requires treatment duration of 60 to 90s.