Non invasive ultrasonic chordal cutting

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Objective Chordal cutting targeting leaflet tethering has been described to improve the efficacy of annuloplasty during ischemic mitral regurgitation surgery. Histotripsy is a novel ultrasound based technique for tissue fragmentation through the cavitation generated at the focus of a very intense ultrasonic pulse. In this study we investigate the feasibility of using histotripsy for chordal cutting to avoid cardiopulmonary bypass and invasive surgery in infarcted heart.

Methods Experiments were performed in vitro in explanted sheep heart (N=5) and in vivo in sheep beating heart (N=3, 40+/-4 kg). In vitro, the mitral valve basal chordae was removed, fixed on a holder in a water tank. The ultrasound pulses were emitted from the therapeutic device (1-MHz focused transducer, pulses of 8µs duration, peak negative pressure of 17 MPa, repetition frequency of 100Hz) placed at a distance of 64 mm.
In vivo, we performed sternotomy and the device was applied on the thorax cavity was filled out with water. We analysed MV coaptation and chordae by real time 3D echocardiography before and after chordal cutting. The animals were sacrificed at the end of the procedure, for postmortem anatomical exploration to confirm the section of the basal chordae and the integrity of the remaining marginal chordae.

Results. In vitro, all the basal chordae were completely cut. The mean procedure time was 6 (+/-3) minutes. The thickness of the chordae was the main criteria affecting the duration of procedure. In the sheep, central basal chordae of anterior leaflet were completely cut. The mean procedure time was 19 (+/-9) minutes. By echography, the sectioned chordae was visible and no mitral valve prolapse was found. All the postmortem anatomical exploration of hearts confirmed the section of the basal chorda. No additional lesions were objectified.

Conclusions Noninvasive ultrasound histotripsy succeed to cut mitral valve basal chordae in vitro and in vivo in beating heart. Future investigations would be needed to test this noninvasive technique on others applications, such atrioseptostomy or valvular stenosis. If positives, this will open the door of completely noninvasive therapeutic technique for these situations.