Application of high-intensity focused ultrasound: Balloon disruption after fetal endoscopic tracheal occlusion
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Objective
Fetal endoscopic tracheal occlusion (FETO) has been reported to be beneficial to patients with congenital diaphragmatic hernia (CDH). It needs highly invasive procedures for balloon removal (fetoscopic and/or ultrasound-guided), and carries a given risk for both mother and fetus. We have reported the potential usefulness of high-intensity focused ultrasound (HIFU) as a noninvasive extracorporeal technology for disrupting intratracheal inflated balloon placed at FETO. In a few cases, it also caused skin burns or damage to the trachea after HIFU irradiation. The purpose of this study was to improve the optimum HIFU system as a noninvasive fetal treatment technology for disrupting intratracheal inflated balloon placed at FETO.

Methods
We investigated the optimum HIFU parameters for disrupting a balloon (GOLDBAL2, BALT EXTRUSION, FRANCE) occluding the trachea of experimental animals. The animals were white male rabbits (adult; weighing 1kg) placed underwater (degassed water) after being pharmacologically sacrificed. The balloon was inflated by injection of Phase-Change Nanodroplet (PCND-US-100LG, HITACHI, Japan). We used two HIFU irradiation methods (vaporization sequence and rupture sequence) for disrupting the balloon. Vaporization sequence makes it easier to rupture the balloon by generating micro-bubbles within it. Rupture sequence supplies the energy efficiently to the balloon.

Results
The balloon was ruptured in all cases. It resulted in no skin burns but occasional damage to the trachea (membranous portion).

Conclusion
Our HIFU delivery system may be considered as a minimally invasive modality for relieving the trachea of balloon occlusion caused by insertion of a FETO. It can be expected to cause no damage to mother or fetus. It is further necessary to define the optimum HIFU delivery setting in order to apply it clinically.