Development of a LUTO training model for US-guided vesicoamnial shunting using modern 3D printing technology

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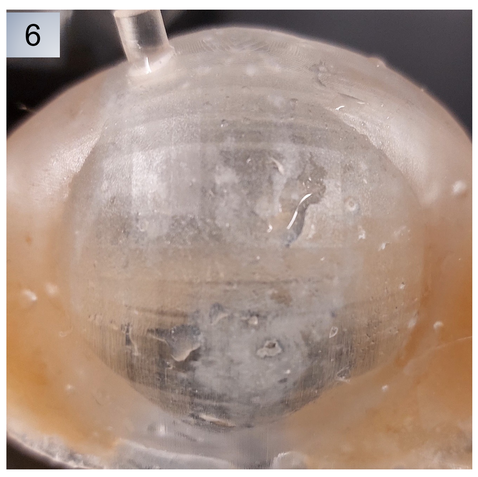
Background

Prenatal lower urinary tract obstruction (LUTO) is a rare but serious condition related to high neonatal morbidity and mortality. Vesicoamnial shunting (VAS) before 14 weeks of gestation is a therapeutic option, which has been shown to reduce neonatal complications and mortality (1, 2). But shunt placement can be challenging and should be performed by expert hand. Since this entity is rare learning curve for this skills can be very slow and it has been always performed on live patients until now. The aim of this study was to develop a training LUTO model for ultrasound guided shunt placement using modern 3D printing technology.

Methods

We developed a 3D printed training model of a fetus in the 14th week of gestation with LUTO using Autodesk Fusion360 software and 3D printer (Formlabs Form3) biased on multiple US pictures from our database. After successful modelling, a latex balloon simulating the bladder was placed inside the model and it was then embedded in a fluid medium, placed in a box and covered with multiple layers of different materials (water, ultrasound transmission gel, latex gloves) simulating different body layers (Fig 1-4). The ultrasound images were compared by ultrasound specialists in the diagnosis of LUTO as well as fetal therapy and punctures were performed.

Figure 1: Different developing states of the punctable modell
Figure 2: Demonstration of the acces for bladder refillll and fixation
Figure 3: Demonstration of the model inside latex glove full with water
Figure 4 a-c: Developement of simulation box



Video 1: Demonstration ultrasound guided puntion
Figure 5: First ulsasound pictres of the simulation box
Figure 6: Demonstration of intact wall of the model after 15 punctions

Results:

The ultrasound simulation model of fetal LUTO inside the box showed similar ultrasound morphology compared to real ultrasound images of fetuses with LUTO and met the prenatal ultrasound definitions regarding bladder volume of fetuses with Megazystis due to LUTO (fig. 5). It could be shown that the puncture of the bladder for placement of a vesicoamniotic shunt was possible in the simulation box model developed and comparable to the realistic shunt placement (Video 1).
After 15 repeated punctures from different positions the model was still intact and presented no ultrasound artefacts due to previous punctures (fig. 6). The model resulted to be inexpensive with production costs of less than 15 €

Conclusion:

We were able to show that the production of a low-cost 3D-printed ultrasound training model is feasible for the prenatal LUTO. It was also shown that such a model is very suitable for future training of a fetal VAS system.
Specially considering that simulation training could help increase puncture skills of doctors independently of the prevalence of the disease and without real patients, an increase of patient securtity can be expected.
Future interventions and teaching studies are needed in order to develope a specific curriculum for training of VAS in facilities.

References

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