Letter to the Editor

Fetal Complex Congenital Heart Disease Diagnosed by Prenatal Ultrasound and Corrosion Casting for Large-Vessels: A Report for Authentic Teaching by True Representation

An et al. CCHD by US, Cast, Authentic Teaching

Peng An, Yu Wang, Li-min Xing, Wei Feng

Department of Ultrasound, Xiangyang No. 1 People’s Hospital Affiliated to Hubei University of Medicine, Xiangyang Key Laboratory of Maternal-Fetal Medicine in Fetal Heart Disease, Hubei, China

* Peng An, Yu Wang, Li-min Xing and Wei Feng contributed equally to this work.

Address for Correspondence: Yu Wang, Department of Ultrasound, Xiangyang No. 1 People’s Hospital Affiliated to Hubei University of Medicine, Xiangyang Key Laboratory of Maternal-Fetal Medicine in Fetal Heart Disease, Hubei, China
e-mail: wangyxyyy@126.com

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Complex congenital heart disease (CCHD) is the most common birth defect. According to the National Maternal and Child Health Care Surveillance report released by the Ministry of Health (China), the incidence of CCHD is continually rising, with an annual increase of approximately 150,000 to 200,000 children. An accurate prenatal diagnosis of CCHD is crucial for determining postnatal surgical plans[1]. Prenatal ultrasound is currently the preferred method for the diagnosis of fetal malformations and abnormalities; however, its accuracy in the diagnosis of CCHD is not optimal. In particular, for certain conotruncal or aortic malformations (such as coarctation or interruption of the aortic arch, transposition of the great arteries (TGA), double outlet right ventricle (DORV), ectopic ductus arteriosus (DA), and aberrant subclavian arteries), it is typically difficult to accurately show vascular travel and spatial adjacent relationships by ultrasound[2,3]. The diagnostic accuracy depends heavily on the experience and technique of the sonographer; therefore, teaching of CCHD diagnosis using simulation is extremely important. However, current routine anatomy lectures can only exhibit CCHD specimens well the very first time, since following immersion fixation, these specimens usually develop deformations, collapses, and damage, and cannot authentically reproduce the vascular morphology of the rare CCHD. Casting can display the true anatomical structure and space confirmation of CCHD; thus, being helpful for teaching and clinical research purposes. It can help physicians to further understand fetal CCHD and has significant value for the accurate diagnosis of this type of disease prior to delivery. Casting also provides an honest morphological basis for prenatal diagnosis, teaching, research, and science popularization[4]. CCHD is mainly characterized by malformations in the heart valves and vascular system, and corrosion casting of large-vessels has an advantage for complex vascular malformations[5,6]. We introduced the pathological results of large vessel casts in one case of CCHD, both of which were natural death specimens after birth(stillbirth or infant death, after intensive treatment and care). The dissection and casting were performed following approval by the Ethics Committee and signed informed consent from the parents and families.

Case: A 30-year-old pregnant women (gravida 1, para 0) at 23 + 5 weeks of gestation. The non-invasive prenatal test results indicated a low risk. The prenatal ultrasound results demonstrated coarctation of aortic arch, DORV, and a small amount of pleural and peritoneal fluid. The vascular cast exhibited DORV and complete TGA, interruption of the aortic arch (not aortic arch constriction), right DA, anomalous DA connections (Left common carotid artery - DA - pulmonary artery), aberrant left subclavian artery (from the descending aorta) and the descending aorta starting from the beginning of the pulmonary artery(Fig.1).
Modified Vascular corrosion casting method: (1). The specimen was washed with running water, and special attention was paid to make sure that the mouth and anal were cleaned, followed by disinfection with 10% Bromo Geramine. (2). Cannulation: the abdominal wall was incised, the umbilical vein was dissected, a “V”-shaped small opening was made and a cannula was introduced into the umbilical vein at the proximal end of heart. The left umbilical artery was dissected and incised to facilitate the outflow of blood, clots and the washout medium. (3). Lumen cleaning: the umbilical vein cannula was flushed with 20-50 ml of acetone to washout the blood and clots and to avoid their interference on the cast in the heart chambers and the vascular lumina. (4) Infusion of casting medium: a total amount of 100-200 ml acrylonitrile butadiene styrene (ABS) resin was slowly infused into the specimen; the infusion took about 30 minutes. (5) Corrosion: after 24 hours after the rein cured, the specimen was immersed in a 30% hydrochloric acid solution for acid etching. (6) Specimen rinse: after 7-10 days, the specimen was removed from the hydrochloric acid solution and carefully rinsed to get rid of the tissues. Then the specimen was soaked in water to eliminate the residues.

Note: (1) Perfusion time: to enhance the perfusion effect, it was desirable to infuse within 24 hours to prevent the blockage from clotting into the vessels and heart chambers, which is generally caused by keeping the specimen for too long. (2) Casting medium concentration: when the concentration of the casting medium was too low, it was easy to infuse, but it shrank too much during solidification, and resulted in a thin and imperfect blood vessel cast. When the concentration was too high, it was difficult to infuse, and resulted in a full cast but with a rough surface that was easy to crack. Therefore, the optimal concentrations of the casting medium should be low (1~3%) initially and then high (5~8%), with a fast infusion at the beginning to a subsequent slow infusion. (3) When air or clots were present in the heart chamber, the ventricle surface can be broken with a needle or cut to make a small incision while the casting medium was in a semi-solid state. After removing the air or clots, a small piece of gauze soaked in casting medium was then filled into the heart chamber to recover its shape[6]. (4) Selection of the appropriate cannula: the scalp needle for children was employed, the needle was removed and the tube was used as the cannula. (Special reminders of limitations: The above perfusion methods are only suitable for specimens above 20 gestational weeks, but not for specimens below 20 gestational weeks.)

Feedback of the casting results is helpful for further analysis and teaching of prenatal ultrasound imaging. Comparison of the casting results with the prenatal ultrasound images showed that many questionable images could be effortlessly explained, improving the accuracy of prenatal diagnosis. Echocardiography has a high accuracy in diagnosing fetal intracardiac malformations, while the vascular casting technique has superiority in displaying complex vascular malformations of CCHD and can be used to guide ultrasound diagnostic teaching.

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Fig. 1a prenatal ultrasound only diagnosed coarctation of aortic arch and double outlet of right ventricle.
Fig. 1b The cast shows interruption of the aortic arch. DA abnormal connections (LCCA - DA - PA).