Prenatal Diagnosis of Complete Vascular Ring Using HD-flow Render Mode and Spatiotemporal Image Correlation(STIC)

Tian-gang Li[1], Quan-lin Li[1], Bin Ma[1], Ping-an Qi[1], Jian Wang[1], and Lan Yang[1]

[1]Gansu Provincial Maternity and Child-care Hospital

July 21, 2020

Abstract

Vascular rings(VRs) are defined as congenital abnormalities of the aortic arch and its branches. The most common vascular rings include right aortic arch (RAA) and double aortic arches(DAA). Vascular rings can form a ring that may compress the esophagus and trachea ,which likely result feeding difficulties and respiratory distress. We have reported three cases about diagnosis of vascular rings using High-definition flow(HD-flow) render mode and spatiotemporal image correlation(STIC). In addition ,we have evaluated the postnatal imaging features of vascular rings.

Keywords:

prenatal diagnosis, complete vascular ring, three-dimensional ultrasound, spatiotemporal image correlation

1 | INtroduction

VRs are congenital vascular abnormalities that are rarely with an incidence of 0.02 to 0.1%[1,2]. VRs include two types: complete and incomplete. Complete vascular ring(CVR) can encircle thoracic esophagus and trachea completely, and can result to compression of the trachea or esophagus. Most infants present with feeding issues or airway obstruction in the first year of birth[3].

2 | CASE REPORT

Case 1: A 32-year-old pregnant woman, gravida 2, para 1, was diagnosed by prenatal fetal echocardiography at 25^{+1} weeks of gestation. An "U"-shaped VR can be seen with RAA, aberrant left subclavian artery (LSA) and left-sided ductus arteriosus (DA) in three-vessel trachea view (Fig 1A). Color blood flow can show the "U"-shaped VR and aberrant left subclavian artery(ALSA) (Fig 1B). Four-dimensional(4D) color Doppler ultrasound ,HD-flow render mode and STIC were used to show VR and ALSA(Fig 1C) . Two-dimensional(2D)ultrasound could demonstrat the ALSA in descending aorta long axis view (Fig 1D). Color blood flow demonstrating the ALSA (Fig 1E). The imaging of RAA and ALSA were shown with HD-flow render mode and STIC(Fig 1F). Amniocenntesis showed no chromosomal abnormality. A male infant was delivered by vaginal delivery with a birth weight of 3610 kg at 39^{+5} weeks of gestation and he has no signs of tracheal and esophageal compression.

Case 2:A 21-year-old pregnant woman,gravida 1, para 0, underwent fetal echocardiography examination at 23^{+5} weeks' gestation due to DAA diagnosed at other hospital by system ultrasound. 2D ultrasound showed an "U"-shaped VR with RAA and left-sided DA by three-vessel trachea(3VT) view (Fig. 2A). Color blood flow could show the "U"-shaped VR and left innocent artery(LINA) (Fig 2B). 4D color Doppler ultrasound ,HD-flow render mode and STIC were used to show VR and LINA (Fig 1C). A female infant was delivered by cesarean section with a birth weight of 3920 kg at 40^{+2} weeks of gestation. The newborn did not show signs of tracheal and esophageal compression also.

Case 3: A 36-year-old maternity, gravida 2, para 1,was performed fetal echocardiography examination at 28 weeks' gestation due to senior pregnant women. RAA with mirror branch was diagnosed. A review of the fetal echocardiogram revealed that the vascular ring was a DAA two weeks later(Figure 3A,3B,3C). A cesarean section was performed at 39^{+1} weeks with the request of the maternity. A male infant weighing 3250g was delivered. The infant present ed of airway obstruction in the first year of birth and computed tomography angiography was performed postpartum, the DAA could be seen (Figure 3D). The child underwent cardiac surgery at the age of one.The left aortic arch was blocked because of the advantage of the right arch and the prognosis was good.

3 | Discussion

The most common CVR is right aortic arch (RAA) and double aortic arch(DAA). RAA includes aberrant left subclavian arteries (ALSA) and mirror-image branching pattern, while ALSA is common[3,4]. The RAA with ALSA can have a Kommerell's diverticulum closely related to 22q11.2 chromosome microdeletion. RAA with mirror-image branching is usually complicated by congenital cardiac anomalies and cases without anomalies are quite rare[5]. DAA has been reported as an association with upper airway obstruction[1].

An accurate diagnosis of CVRs can be made prenatally by fetal echocardiography[6]. The three-vessel and tracheal(3VT) view are the 'gold standard' to observe arch anomalies[7]. Fetal CVRs can be assessed by a four-dimensional (4D) spatiotemporal image correlation (STIC) technique with high-definition(HD) flow imaging[8]. Once an aortic arch anomaly is diagnosed, a comprehensive ultrasound examination, including fetal echocardiography is recommended to finding potential structural malformation[9,10]. According to the type of VR,prenatal counseling on chromosome examination and postnatal airway assessment are recommended[11,12].

RAA with ALSA can be accurate diagnosed by "U"-shaped VR and ALSA. The RAA with mirror branch is often mistaken for a DAA when the arterial ductus flows into the descend aorta and forms an "U"-shaped VR. The color blood flow is likely to mistaking the cross relationship between the left innocent artery(LINA) and the arterial ductus for anatomy connection which may lead to misdiagnosis. Although most of the infants with the RAA mirror branch are asymptomatic, DAA is often related to compression symptoms of esophagus or trachea. If the RAA with mirror branch is misdiagnosed as a DAA, it may lead to excessive abortion or unnecessary worry of pregnant women. The author believes that the RAA with mirror branch should be diagnosed by following criteria: 1): 3VT view shows RAA and the left side ductus arch forming a "U"-shaped VR, without a ALSA; 2): the first branch of the aortic arch begins with the LINA and the LINA straightly moves to the left. 3): Continuous scanning of the aortic arch view and the long axis view of the ductus arch show that the LINA is not connected to the descend aorta or arterial ductus and is not formation of VR.

In addition, DAA is usually combined with the right arch dominant type and it is common to misdiagnose DAA as an RAA with mirror branch when the left arch is thin or the arterial duct is thick because of the left arch is not easy to display, as in our third case. The authors believe that the DAA should be diagnosed by following criteria: 1): 3VT view shows that the left and right aortic arches form an "O"-shaped VR encircling the trachea and esophagus; 2): The arterial ductus is located on the left side of the left aortic arch, 3) DAA and the left ductus are all connected to the descend aorta.

Ethical approval

This study has been granted an exemption from the Medical Ethics Committee of Gansu Provincial Maternity and Child-care Hospital. The pregnant mothers provided their written informed consent to publish their cases (including publication of images).

Acknowledgments:

Not applicable

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

Funding

This work is supported by National Key Research and Development Program of China (grant 2018YFC1002504), Lanzhou Science and Technology Program (grant 2017-4-53)

ORCID

Tian-gang Li. https://orcid.org/0000-0003-4384-9701

References

1. Doan TT, Wang A, Davey B, et al. Two Cases of a Prenatally Diagnosed Double Aortic Arch with Postnatal Obliteration of the Distal Left Aortic Arch. Pediatr Cardiol. 2019;40(8):1748–1751.
2. Young AA, Hornberger LK, Haberer K, et al. Prenatal Detection, Comorbidities, and Management of Vascular Rings. Am J Cardiol. 2019;123(10):1703–1708.
3. D'Antonio F, Khalil A, Zidere V, et al. Fetuses with right aortic arch: a multicenter cohort study and meta-analysis. Ultrasound Obstet Gynecol. 2016;47(4):423–432.
4. Dong SZ, Zhu M. Prenatal cardiac magnetic resonance imaging of right aortic arch with mirror image branching and retroesophageal left ductus arteriosus. J Matern Fetal Neonatal Med. 2019;32(7):1057–1062.
5. Nakata M, Suzuki Y, Hotta N, , et al. Prenatal diagnosis of right aortic arch with mirror-image branching without associated anomalies. J Obstet Gynaecol Res. 2013;39(5):1077–1080.
6. Mogra R, Kesby G, Sholler G, et al. Identification and management of fetal isolated right-sided aortic arch in an unselected population. Ultrasound Obstet Gynecol. 2016;48(6):739–743.
7. Wohlmuth C, Gardiner HM. The biplane mode: it takes two to tango. Ultrasound Obstet Gynecol. 2017;49(4):540.
8. Tseng JJ, Peng HW, Jan SL. An In-depth Perspective of Aortic Arch Branching in Fetal Vascular Rings Using Spatiotemporal Image Correlation Combined With High-definition Flow Imaging: Report of 4 Cases. J Ultrasound Med. 2019;38(8):2217–2224.
9. Miranda JO, Callaghan N, Miller O, et al. Right aortic arch diagnosed antenatally: associations and outcome in 98 fetuses. Heart. 2014;100(1):54–59.
10. Trobo D, Bravo C, Alvarez T, et al. Prenatal Sonographic Features of a Double Aortic Arch: Literature Review and Perinatal Management [published correction appears in J Ultrasound Med. 2016 Jun;35(6):1352]. J Ultrasound Med. 2015;34(11):1921–1927.
11. Vigneswaran TV, Allan L, Charakida M, et al. Prenatal diagnosis and clinical implications of an apparently isolated right aortic arch. Prenat Diagn. 2018;38(13):1055–1061.
12. Razon Y, Berant M, Fogelman R, et al. Prenatal diagnosis and outcome of right aortic arch without significant intracardiac anomaly. J Am Soc Echocardiogr. 2014;27(12):1352–1358.

Figure legends

Figure 1:

Case 1: Prenatal image of RAA with ALSA using 2D ultrasound and 3D ultrasound. (A) 2D ultrasound demonstrating the "U"-shaped VR. (B) Color blood flow demonstrating the "U"-shaped VR and aberrant left subclavian artery(ALSA). (C) The imaging of VR and ALSA was shown using HD-flow render mode and STIC. (D) 2D ultrasound demonstrating the ALSA with Descending aorta long axis view. (E) Color blood flow demonstrating the ALSA. (F) The imaging of RAA and ALSA was shown using HD-flow render mode and STIC. L: left, R: right, Ce: cephalic, Ca: caudal. A: abdominal, P: spinal

Figure 2:

Case 2: Prenatal image of RAA with mirror-image branching. (A) Color Doppler blood flow of "U"-shaped VR. (B) 3D ultrasound of the imaging demonstrating the first branch on the RAA is the LINA. (C) 4D color Doppler ultrasound HD-flow render mode and STIC was used to show the "U"-shaped VR and LINA. L: left, R: right, Ce: cephalic, Ca: caudal. A: abdominal, P: spinal

Figure 3

Case 3: Prenatal image of DAA. (A) Color blood flow demonstrated the right aortic arch(RAA) and left aortic arch(LAA), forming a classic 'O' shape. (**B-C**) The image of HD-flow render mode and STIC demonstrated DAA encircling esophagus and trachea completely. (**D**) The computed tomography angiography of DAA demonstrated the RAA and LAA. L: left, R: right, Ce: cephalic, Ca: caudal. A: abdominal, P: spinal