CEOG Clinical and Experimental Obstetrics & Gynecology

Cardiac failure of the twin reversed arterial perfusion sequence pump twin during the first-trimester: a case report

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Summary

This article reports a case of prenatal ultrasonographic diagnosis and monitoring of the twin reversed arterial perfusion (TRAP) sequence pump twin and describes progression of the disorder to a severe heart failure and fetal death. Genetic analyses were also performed for both fetuses by array-based comparative genomic hybridization (aCGH).

Key words: Acardiac twin; Twin reversed arterial perfusion (TRAP); Array-based comparative genomic hybridization (aCGH).

Introduction

Twin reversed arterial perfusion (TRAP) sequence is a severe complication of monozygotic twin gestations. TRAP sequence can be diagnosed by prenatal ultrasonography during the first-trimester, however, without intervention, mortality rates for pump twins can be as high as 55% [1].

Revealed by prenatal ultrasonography, the TRAP sequence consists of a severely deformed fetus (the acardiac twin) - lacking defined cardiac structures but with signs of blood flow internally and in the umbilical vessels - and a relatively normally structured fetus (the pump twin). Due to the increased circulatory demands of supplying blood to the acardiac twin, the pump twin usually demonstrates bicuspid and tricuspid regurgitation, a reversed "a" wave of the venous duct, and other manifestations of congestive cardiac failure [2]; in severe cases, intrauterine fetal death may result. However, early fetal death, caused by severe edema, ascites, cardiac enlargement, and cardiac functional insufficiency, is relatively uncommon for pump twins during the first-trimester of pregnancy. Trisomy of chromosome 2 in all cells has been reported for the TRAP sequence acardiac twin and this aneupoidy was likely an etiological factor for the TRAP sequence [3].

This article reports a case of prenatal ultrasonographic diagnosis and monitoring of the TRAP sequence pump twin and describes progression of the disorder to a severe heart failure and fetal death. Genetic analyses were also performed for both fetuses by array-based comparative genomic hybridization (aCGH).

Case Report

Patient history

A 21-year-old pregnant woman, had one previous pregnancy without birth, generally in good health, regular menstruation, and no family history of genetic disorder or twins.

Ultrasonography examination

An intrauterine gestational sac echo of 2.1×1.0 cm was observed during the first 2D ultrasonography at a postmenstrual duration of 42 days, which showed a visible yolk sac, some embryo, but no cardiac tube pulses.

During the second 2D ultrasonography at seven weeks and five days of gestation, an intrauterine gestational sac echo of 3.3×4.3×1.1 cm was observed showing two visible yolk sacs and two embryo echoes, and a visible "T" formed narrow light band at the inter-fetal membrane-placental junction. The larger embryo (fetus A) was 1.4 cm long and showed cardiac tube pulses, whereas no cardiac tube pulses were detected for the other 1.0 cm long embryo (fetus B). An early intrauterine pregnancy was suggested by the ultrasonography (monochorionic and diamniotic twins, with one surviving fetus and one embryo which had ceased to develop).

A third 2D ultrasonography and a color Doppler ultrasonography showed monochorionic and diamniotic twins at 13 weeks and five days of gestation. The pump twin, which was equivalent to a normal fetal size at 14 weeks and three days of gestation, had a biparietal diameter of 2.7 cm with a 9.7-cm head circumference, an abdomen circumference of 8.8 cm, a femur length of 1.2 cm, and a cerebellar transverse diameter of 1.26 cm. Systemic hydroderma was detected, and with a nuchal translucency thickness of 0.39 cm (Figure 1). Several separated anechoic areas were observed in the neck (Figure 2) and the skin thickness of the chest and the abdomen was 0.5 cm. The nasal bone was 0.27 cm long and the inner diameters for the left and right encephalocoeles were 0.66 cm and 0.53 cm, respectively. Minor effusion was detected in the abdominal cavity (Figure 3).

Revised manuscript accepted for publication February 11, 2015

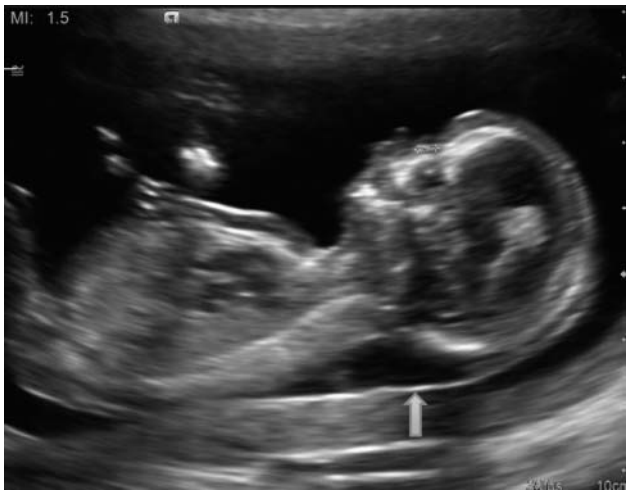

Figure 1. — The middle sagittal section of the pump twin at 13 weeks and five days of gestation. Apparent increase in the bodiness of the NT value is indicated by the arrow and the measurement point is the nasal bone.

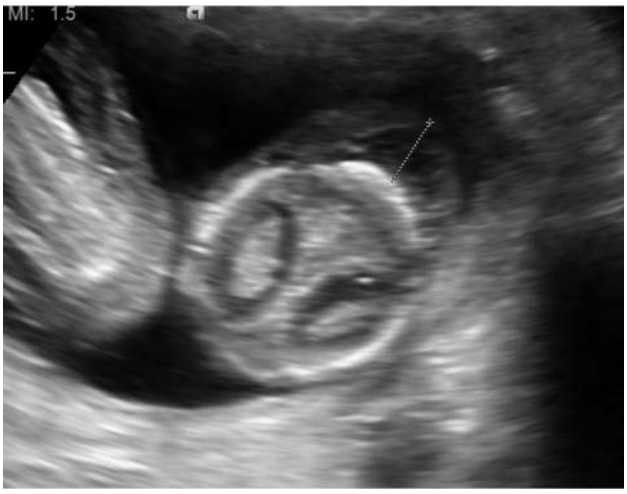

Figure 2. — The transaction of the pump twin's head at 13 weeks and five days of gestation, which shows lymphatic hygroma.

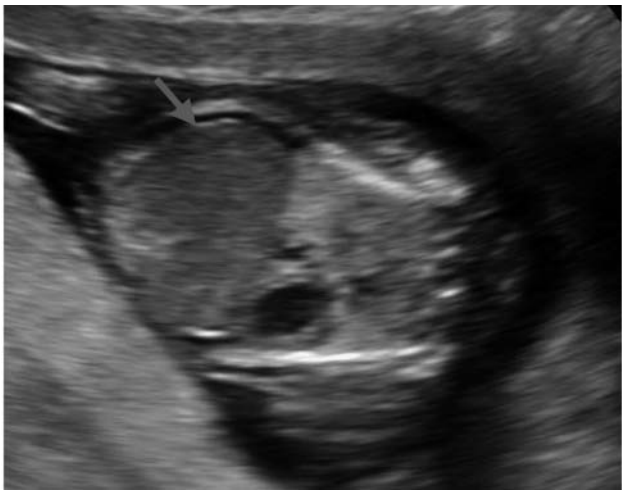

Figure 3. — The transaction of the pump twin's abdomen at 13 weeks and five days of gestation, which shows effusion in the abdominal cavity (indicated by the red arrow).

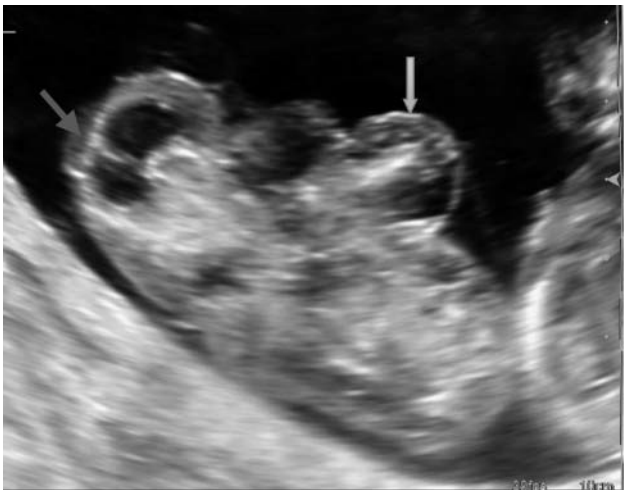

Figure 4. — The coronal section of the acardiac twin at 13 weeks and five days of gestation. The dysplastic head is indicated by the red arrow whereas the blue arrow indicates the dysplastic upper limb.

The heart was enlarged with a 0.41-cm left atrium, a 0.35-cm left ventricle, a 0.53-cm right atrium, a 0.54-cm right ventricle, and a cardiothoracic ratio of 66% (1.3 / 2.0). Irregular ventricular motion was detected but with no obvious cardiac structural abnormities. The highest blood flow was 46.6 cm/s for the pulmonary artery and 33.4 cm/s for the aorta. The flow speed for the mitral orifice during the diastolic period was 26.6 cm/s for the E peak and 43.3 cm/s for the A peak. The flow speed for the tricuspid during the diastolic period formed a single peak, where the highest flow speed was 34.4 cm/s. An aqueous dark area with an anteroposterior diameter of 0.26 cm was observed in the cavum pericardii. No blood flow was detected in the cerebral artery during the diastolic period, where the highest flow speed was ten cm/s. A reversed blood flow signal was observed on the "a" wave for the venous duct. The umbilical cord was twisted and had a diameter of 0.57 cm, and a reversed flood flow was shown in the umbilical artery during the diastolic period. The fetal heart was arrhythmic, with no obvious rhythm, and the heart rate was 144 beats/minute.

No cardiac structures or pulses in the cardiac tube were observed for the acardiac twin. Systemic hydroderma was detected and lymphedema was also observed. A halo echo was observed for the skull, but clear encephalic structures were not apparent. Only a single encephalocoele was seen with an approximate area of 1.7×2.0 cm, and nephritic renal and minor intestinal canal echoes were observed (Figure 3). The left upper limb was not clearly shown and the right upper limb was dysplasic. The humerus was approximately 1.8 cm long and the radius was absent. The posture

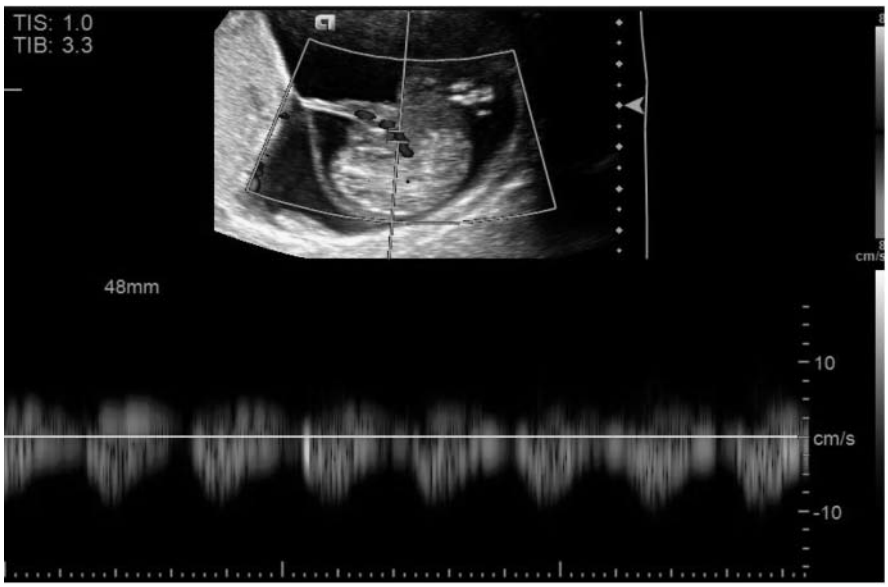

Figure 5. — Reversed blood flow signal of the umbilical artery in the acardiac twin (blue color is deviated from the probe) and the signal spectrum (signal is below the baseline).

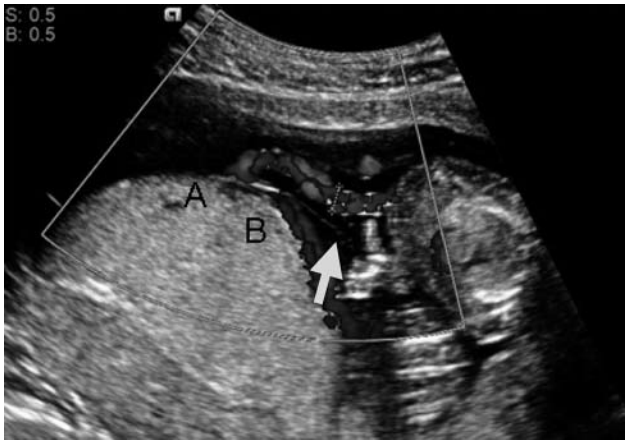

Figure 6. — Umbilical cord and placenta attachment points for both fetuses and the amnionic light band. The umbilical cord attachment point for the pump twin is indicated by A. B indicates the umbilical cord attachment point for the acardiac twin, which shows a single umbilical artery. Both points are closely located and show communications. The amnionic light band is indicated by the yellow arrow.

for the left hand was abnormal and showed a deviation toward the radial side (Figure 4). Both lower limbs were seen, and blood flow signals were also detected internally and in the umbilical vessels. A "double-square" shape was formed by the transection of the umbilical cord and was displayed as "one blue and one red" on the color Doppler ultrasonography. The umbilical cord was approximately 3.4 cm long with an approximate diameter of 0.37 cm. A small turbulence was detected in the umbilical vein, and the direction of flow in the umbilical artery was reversed into the fetal body with a rate of 155 beats/minute (Figure 5). Attachment sites for both fetal umbilical cords were closely located and showed blood vessel interconnections. Only one placenta was observed, positioned at the posterior wall of the uterus and this was 2.8-cm thick. A thin amniotic band was seen between the two fetuses, demonstrating a "T" form (Figure 6), and the quantity of amniotic fluid was normal for both fetuses.

Ultrasonography diagnoses were: 1) twins (monochorionic and diamniotic twins with TRAP sequence); 2) the pump twin had systemic hydroderma, lymphatic hygroma, a minor effusion in the abdominal cavity, no blood flow in the cerebral artery during the diastolic period, a reversed flood flow in the umbilical artery during the diastolic period, a reversed "a" wave for the venous duct, cardiac enlargement, arrhythmia, a minor pericardial effusion, and possibly a twisted umbilical cord; 3) the acardiac twin had systemic hydroderma, lymphatic hygroma, acardia, a dysplastic head, a complete proencephalon, no left upper limb, a dysplastic right arm, both lower limbs, a short umbilical cord, and a single umbilical artery. Chromosomal test and TORCH were suggested for both fetuses.

The pump twin was still alive at a re-examination at 14 weeks and four days of gestation. The ultrasonography showed a similar pattern to the previous one and the fetal size was equivalent to that of a normal 15-week gestation. Pulses were observed in the outer section of the umbilical vein in the abdomen. The crown-rump length for the acardiac twin was 6.9 cm long, which was equivalent to a normal 13-week gestation. Intrauterine blood flow had spontaneously blocked, and no blood flow signals were observed internally or in the umbilical cord vessels. Lamellar aqueous dark areas were observed in the intracalvarium, but with no clear encephalic tissues shown. The splanchnocoele structure was not clearly shown, the spine was misaligned, and other structural features were consistent with the previous examination.

Intrauterine fetal deaths were observed for both fetuses during the subsequent examination at 15 weeks of gestation.

Autopsy results

One hundred ml of ethacridine lactate was injected into the amniotic cavity under the guidance of the ultrasonography. Two macerated female fetuses were induced along with a placenta, which was approximately 13×8.5×1.5cm in size and weighed 77 grams, with two amniotic sacs. Both fetuses had the appearance of edema and lymphatic hygroma, which showed segmentation when the hygromas were cut. The pump twin was 13 cm long, weighed 50

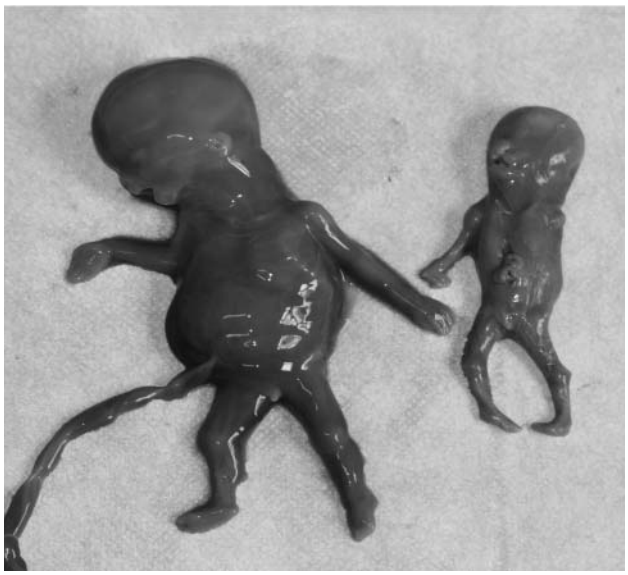

Figure 7. — Specimens obtained after the induced labor. The structural normal specimen on the left side is the pump twin, whereas the smaller acardiac twin is on the right side.

Figure 8. — X-ray results obtained after induced labor. The acardiac twin is on the right side, which shows no left upper limb and a missing radius on the right upper limb.

grams and with no apparent deformities. The heart was enlarged but with no apparent cardiac structural deformities. No apparent deformities were observed during general dissection of the internal organs. The umbilical cord was 12 cm long with three umbilical cord vessels, and the turning diameter of the fetal umbilical cord at the abdominal umbilical ring was 0.2 cm.

The crown-rump length for the acardiac twin was 6.5 cm long and it weighed 12 grams. No apparent umbilical cord was observed, which was possibly too thin and was broken during the induced labor. A head was formed for the acardiac twin but with no eyes, ears and apparent nasal cavity, and showed cheilopalatognathus. The right upper limb had four fingers but was missing a radius. The upper left had a stump which was 1.0 cm long. Both lower limbs were formed with equinovarus on the left lower limb (Figure 7). Dissection of the internal organs showed adrenal glands on both sides, two kidneys, some intestinal ducts, a uterus, and ovaries and fallopian tubes on both sides. X-ray examinations clarified that the acardiac twin had a skull, but with no apparent left upper limb bones and a missing radius on the right upper limb, and a lateral curvature on the left side of the spine (Figure 8).

Chromosome karyotypes were normal for both the pregnant woman and her spouse (results not shown). Genetic analyses were carried out by aCGH using DNA extracted from thymus glands of both fetuses. Sixty K commercial arrays were used, which contained 60-mer oligonucleotide probes spanning the entire human genome and with an overall mean probe spacing of 50 kb. aCGH analyses were performed in accordance with the manufacturer's instructions and no chromosomal aberrations were detected for both fetuses (results not shown).

Discussion

The pathophysiologic mechanism of the TRAP sequence is not clearly known, only that it occurs exclusively during monozygotic twin gestations, but the "reversed arterial perfusion" theory is widely accepted. According to the theory, the pump twin is rich in oxygenated blood which flows from the mother into the fetus through the umbilical vein. After circulating in the fetus, the deoxygenated flood flows back to the placenta through the umbilical artery. However, through major fetal arterial-to-arterial and venous-to-venous anastomoses, deoxygenated blood also flows into the acardiac twin via the acardiac twin's umbilical artery. Cardiac failure can result for the pump twin as it needs to provide its own and the acardiac twin's blood circulations. The acardiac twin receives relatively oxygen-rich blood in the lower body through the internal iliac artery, therefore its lower limbs and abdomen are relatively well-developed. The upper body however shows various forms of severe deformities as it lacks blood and oxygen [4].

There are many variations of the TRAP sequence acardiac twins, and the most common seen deformities are acephalus, acardiac acephalus, and holoacardius. In the reported case, the acardiac twin had a dysplastic head with some facial organs, upper limbs developed more poorly than lower limbs, but had both kidneys and intestinal ducts, which fitted the "reversed arterial perfusion" theory, and despite various deformities, no chromosomal aberrations were detected.

Acardiac twins cannot survive after birth when the intrauterine blood flow stops, but the prognosis for the pump twin can be affected by many factors. Prognosis is not affected by the degree of deformity of the acardiac twin, but rather by the speed of development and the increasing circulatory demands of the acardiac twin. The prognosis is

also related to the cardiac function of the pump twin, and presence of chromosomal anomalies for both twins, and fetal auxiliary structures such as the placenta, the umbilical cord, and the amniotic fluid are other important aspects [5, 6]. In the reported case, spontaneous blockage of the intrauterine blood flow to the acardiac twin occurred during the first-trimester. The pump twin had systemic hydroderma, lymphatic hygroma, an enlarged heart and features of other severe heart failure, and a twisted umbilical cord. Prenatal chromosome karyotypings were not performed for both fetuses, and poor prognosis and fetal death for the pump twin were consistent with literature reports.

It is possible to misdiagnose a twin gestation with a single gestation during the early first-trimester and, in the reported case, a single gestation was mistakenly diagnosed during this early period. A twin gestation was diagnosed at seven weeks and five days of gestation when it was possible to distinguish as monochorionic and diamniotic twins. One fetus had edema and no fetal heart, and the embryonic development for one of twins had ceased. At 13 weeks and five days of gestation, the embryo which had ceased to develop was still growing, and the color Doppler ultrasonography showed blood flow internally and in umbilical cord vessels in the fetus lacking cardiac structures, which led to the diagnosis of TRAP sequence. The diagnosis of this case highlights the need in determine the nature of the chorions and amniotic sacs of twins during the first-trimester. Monochorionic and diamniotic twins are frequently associated with complications and have a poor prognosis. Therefore re-examinations must be performed every fortnight. TRAP sequence can be diagnosed when one of the twin fetuses is lacking cardiac structures and pulses, and shows severe deformities, especially with systemic edema, lymphatic hygroma, and absence of a head and upper limbs. Color Doppler ultrasonography also needs to show blood flow signals internally and in umbilical cord vessels in the fetus lacking cardiac structures. Spontaneous blockage of the intrauterine blood flow can occur for the TRAP sequence acardiac twin, and when this occurs, special focus is needed for the prognosis of the pump twin starting with weekly re-examination until the acardiac twin ceases to grow and the pump twin is developing properly. When the blood flow was blocked for the acardiac twin in this case, edema was not reduced for the pump twin, and intrauterine fetal death had occurred one week after. Furthermore, auxiliary structures for the TRAP sequence twins are other important observation matters. Blood vessel networks between umbilical cord vessels on the surfaces of both fetal placentas can be directly observed by the prenatal ultrasonograph. Regarding the diameters of both fetal umbilical cords, the umbilical cord is usually narrower for the acardiac twin and with a single umbilical artery. A twisted umbilical cord was observed in this case for the pump twin, however further case studies are required to substantiate whether this twist has any association with the heat failure and fetal death seen with the pump twin during the first-trimester.

Whether survival can be improved for pump twins by correct diagnosis and early intervention during the first-trimester is currently a hot research topic for the TRAP sequence. The TRAP sequence can be diagnosed and monitored at an early stage by the prenatal ultrasonography, which provides clinicians with the options to choose the most effective treatment method and provides reliable information for the prognosis of the pump twins.

Acknowledgement

This project is supported by the Hubei Province Natural Science Fund (2014CFB210).

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