

Abnormalities in embryological development in total anomalous pulmonary venous connection. A case report

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Abstract

Pulmonary venous system development starts early in embryonic life. Abnormalities in the development of pulmonary venous system occur either by the absence of common pulmonary vein communication to the splanchnic plexus or by the absence of its incorporation into the dorsal wall of the left atrium. We present the case of a 10-day-old male newborn, diagnosed with TAPVC, operated, with long recovery and, who died by pneumonia, heart failure, and obstructive pulmonary disease (one pulmonary vein obstructed and another one with severe stenosis). Total anomalous pulmonary venous connection (TAPVC) reflects one of the most severe forms of congenital heart disease, with important clinical consequences.

Keywords: pulmonary venous system, embryology, congenital heart disease.

Introduction

The heart begins to develop early in embryonic life, beats being registered in the 3rd week of development. The most important processes in human heart are registered in the first six weeks of embryogenesis [1, 2]. At the beginning of the fourth week of embryonic life, there is perfect symmetry between the right and left sides of the embryo body with respect to the three venous systems (umbilical system – from the chorion, the vitelline veins – from the yolk sac, the cardinal veins – from the embryo). Subsequently, these systems will anastomose and will regress in some areas, ultimately leading to the fetal venous system. Total anomalous pulmonary venous connection (TAPVC) is a congenital heart defect consisting in the absence of the connection between pulmonary veins and left atrium. These veins form a collector, which drains in the right atrium through three possible ways: supracardiac, cardiac or infracardiac. TAPVC can be explained by common pulmonary vein atresia, which appears early, while there is still communication between pulmonary and splanchnic venous plexuses. Collateral channels appear and persist in the form of a primitive connection between splanchnic plexus and the cardinal venous system or the umbilico-vitelline system. Any of these collateral channels may persist or enlarge, causing TAPVC [3–5].

Patient, Methods and Results

A 10-day-old male newborn was admitted in Neonatal

Intensive Care Unit with severe pulmonary distress and severe pulmonary hypertension. Echocardiography and angiographic computerized tomography (angioCT) examination established the diagnosis of TAPVC, through infracardiac vertical vein collector, which drained into the portal vein. After stabilization, he was transported and operated in Bad Oyenhausen, Germany. The collector was implanted into the left atrium, followed by closure of both patent foramen ovale and persistent ductus arteriosus. The recovery was long: seven days of mechanical ventilation and another 17 days of continuous positive airway pressure (CPAP). The patient continued to present pulmonary hypertension and hypoplastic left cardiac chambers.

Soon after he was discharged from Germany, he presented fever (38.6°C), cough, and pulmonary respiratory distress. Initially, pneumonia was considered (right lobar pneumonia on the chest X-rays). He developed heart failure. The consequent echocardiographic examination revealed enlarged RA and RV, small left chambers, hypertrophy of the RV, and turbulent flow in the collector vein. The flow velocity in the collector vein was 2.6 m/s compared to 2.2 m/s in the early postoperative period. Pulmonary vein stenosis was suspected but the patient's state aggravated and he died.

At necropsy, we found pneumonia. Cardiac chambers were hypoplastic (Figure 1) the implantation of the pulmonary veins collector was normal but one pulmonary vein was occluded, and another one was severely stenotic (Figure 2).

In light microscopy, the left atrium wall shows thin myocardial layer (Figure 3). The stenotic pulmonary vein,

close to the confluence with the left atrial wall, reveals fibroblastic proliferation and edema (Figures 4 and 5).

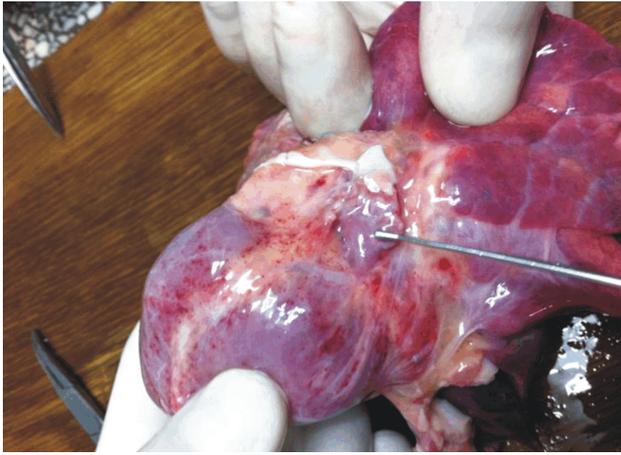


Figure 1 – Hypoplastic left atrium.

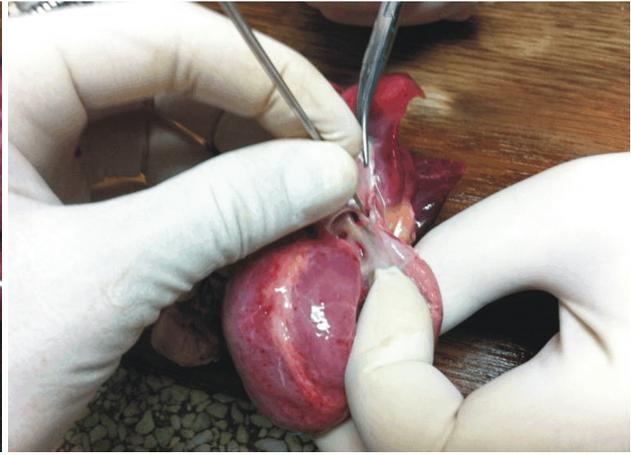


Figure 2 – Pulmonary veins obstruction and stenosis.

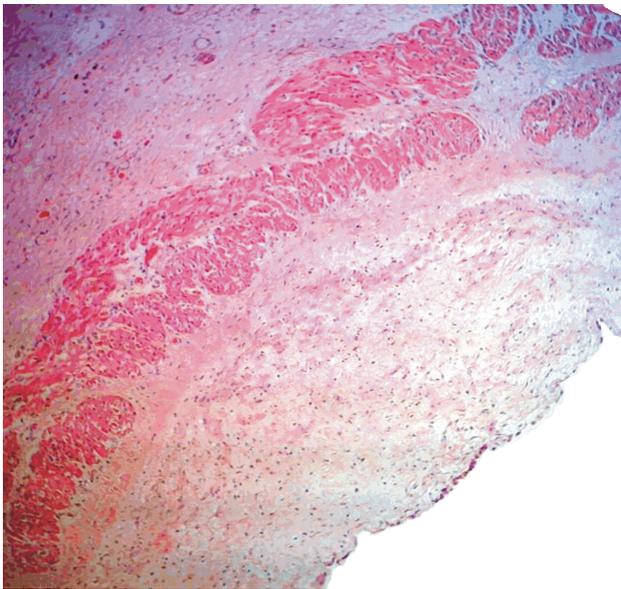


Figure 3 – Left atrium wall section: thin myocardial layer (HE stain, ob. 20×).

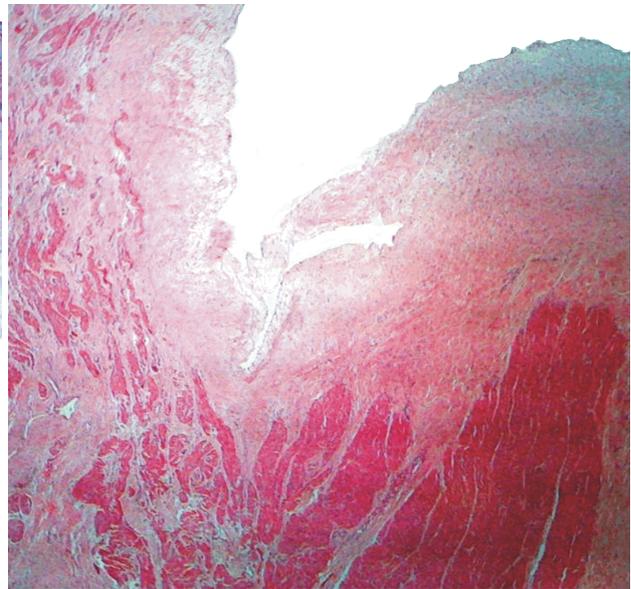


Figure 4 – Left atrium and pulmonary vein section (HE stain, ob. 10×).

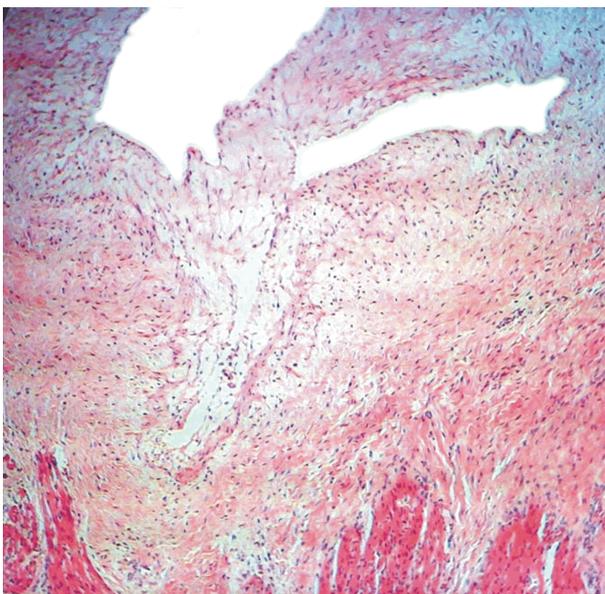


Figure 5 – Detail: stenotic pulmonary vein with edema and fibroblastic tissue proliferation (HE stain, ob. 20×).

Discussion

Embryologically, fetal venous system anomalies are classified into four groups: abnormal connection of the cardinal veins (complex or isolated malformations, heterotaxy syndromes), umbilical vein abnormalities (abnormal inferior vena cava, iliac veins), abnormal vitelline veins (anomalies of the portal system – extremely rare), abnormal pulmonary vein (total or partial abnormal pulmonary veins connection).

Although in terms of classification of TAPVC, we talk about supracardiac (44%), infracardiac (26%), cardiac (21%), and mixed (9%) forms, the classification as non-obstructive and obstructive (48%), most commonly associated with the infracardiac form (78%), prevails in hemodynamics [6].

Several theories are discussed regarding the formation of the pulmonary venous system. The theory accepted by most authors, based on animal models and human studies, proposes several stages of development of the pulmonary venous system: (1) formation of lung buds, allowing draining of the blood into the splanchnic plexus, which

communicates with the cardinal and the umbilico-vitelline system, (2) interruption of the communication between the splanchnic plexus and the cardinal and the umbilico-vitelline systems, (3) formation of the common pulmonary vein in the dorsal side of the left atrium, which will then communicate with the pulmonary draining part of the splanchnic plexus, (4) formation of the four pulmonary veins from the common pulmonary vein [7, 8].

Errors in these processes lead to abnormalities in the formation of the pulmonary venous drainage system. If the common pulmonary vein will fail to communicate with the splanchnic plexus and if the communication will persist with cardinal or umbilico-vitelline system then will meet different types of total or partial anomalous pulmonary venous return. If there is a defect regarding the common pulmonary vein incorporation into the dorsal portion of the left atrium, it will result in stenosis/atresia of the pulmonary veins or cor triatriatum.

Our case was an infracardiac-type TAPVC, with pulmonary veins obstruction. This case reflects both defects: the common pulmonary vein incorporation into the dorsal portion of the left atrium, and the anomaly regarding the communication between the pulmonary part of the splanchnic plexus and the common pulmonary vein, which eventually drained into the umbilico-vitelline system (portal vein).

Some aspects in the development of pulmonary venous system are still debated. Traditionally, it was thought that the primitive common pulmonary vein develops from the dorsal wall of the left atrium. Recently, the direct connection between pulmonary veins and venous system (in chicken and rats) was described using the HNK1 expression (human natural killer antigen 1). This however could not be distinguished in mice, where the classical theory is preserved, with respect to the development from the dorsal wall of the left atrium [2]. Subsequently, the venous sinus is incorporated in the atrium, especially the posterior wall of the right atrium, and can be easily recognized by means of the presence of smooth morphological structures deprived of pectinated muscles [2, 9].

Factors favoring pulmonary vein obstruction are expressed by the intrinsic narrowing of abnormal vessel walls (as is often the case), external pressure, common pulmonary venous connection (collector) to the venous duct (which normally undergoes postnatal constriction), connection to the portal system or its branches (interposing liver sinusoids increases resistance pulmonary venous system), ascending or descending vertical vein length, small ASD [3, 6, 10]. These factors cause vascular obstructive disease.

Conclusions

Unfavorable evolution in the context of pulmonary vascular obstructive disease is common in infracardiac-type of TAPVC. Pulmonary vein stenosis in this cardiac disease was unrelated to the surgical act but was caused by the embryological defect in development of the pulmonary venous system.

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