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# Clinical Diagnosis and Treatment of 5 Cases of TAPVC in Infants

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## ABSTRACT

**Objective:** To explore the clinical diagnosis and treatment methods of supracardiac total anomalous pulmonary venous connection (TAPVC) in infants aged less than 1 year old.

**Methods:** To retrospectively analyse the clinical data of 5 cases of supracardiac TAPCV in infants admitted to Xi'an International Medical Center Hospital (3) and The First Affiliated Hospital of Henan University (2) from October 2019 to October 2023.

**Results:** The 5 cases were all infants less than 1 year old, with clinical manifestations of shortness of breath or recurrent pneumonia episodes. The 5 cases were examined by cardiac ultrasonography or CTA after examination by the first physician, and all of them were diagnosed with TAPVC (supra-cardiac type) and arterial ductus arteriosus or ventricular septal defects. The 5 cases underwent a TAPCV correction with a limited period of multidisciplinary consultation (MDT) before surgery, and all made good postoperative recovery.

**Conclusion:** Parents should be alert to the possibility of congenital heart disease in newborns with shortness of breath, foaming or recurrent pneumonia in infancy. The prognosis of infants with TAPVC is often poor, and the mortality rate is substantially increased due to the untimely diagnosis of preoperative pulmonary venous obstruction (PVO). Precise prenatal examination, professional education on children's prevalent heart diseases, excellent surgical skills and postoperative intensive cardiological care for children are important for making early diagnosis and treatment of supracardiac TAPVC in infants and for improving the postoperative survival rate of children with TAPCV in infants.

## INTRODUCTION

Total anomalous pulmonary venous connection (TAPVC) is a rare form of cyanotic congenital heart disease in which all of the pulmonary veins are unconnected to the left atrium and all of them open into the right heart chambers and/or the vena cava of the body circulation, resulting in the return of oxygenated blood to the right heart rather than the left heart. Shortness of breath, cyanosis, and recurrent respiratory infections are the main clinical manifestations.

## DATA AND METHODS

### Study subjects

Data were collected on all the cases diagnosed with TAPVC under the age of 1 year in the case base of Xi'an International Medical Center Hospital (3) and The First Affiliated Hospital of Henan University (2) from October 2019 to October 2023. Eventually, a total of 5 children with TAPVC (supracardiac type), aged 3 days-97 days, with a median age of 63 days, were included in this study.

### Methods of study

Records were taken and analysed in respect of age, chief complaint, etiology, preoperative imaging manifestations, and postoperative results (see Table 1).

### Clinical manifestations

All patients were admitted to the hospital with shortness of breath or recurrent pneumonia episodes, of which three were combined with fever, but there were no cases of infectious shock.

### Imaging manifestations

All children underwent cardiac ultrasound and CTA after admission. The results of cardiac ultrasound and CTA were: supracardiac TAPVC with ductus arteriosus or atrial septal defect or patent foramen ovale (see Figure 1).

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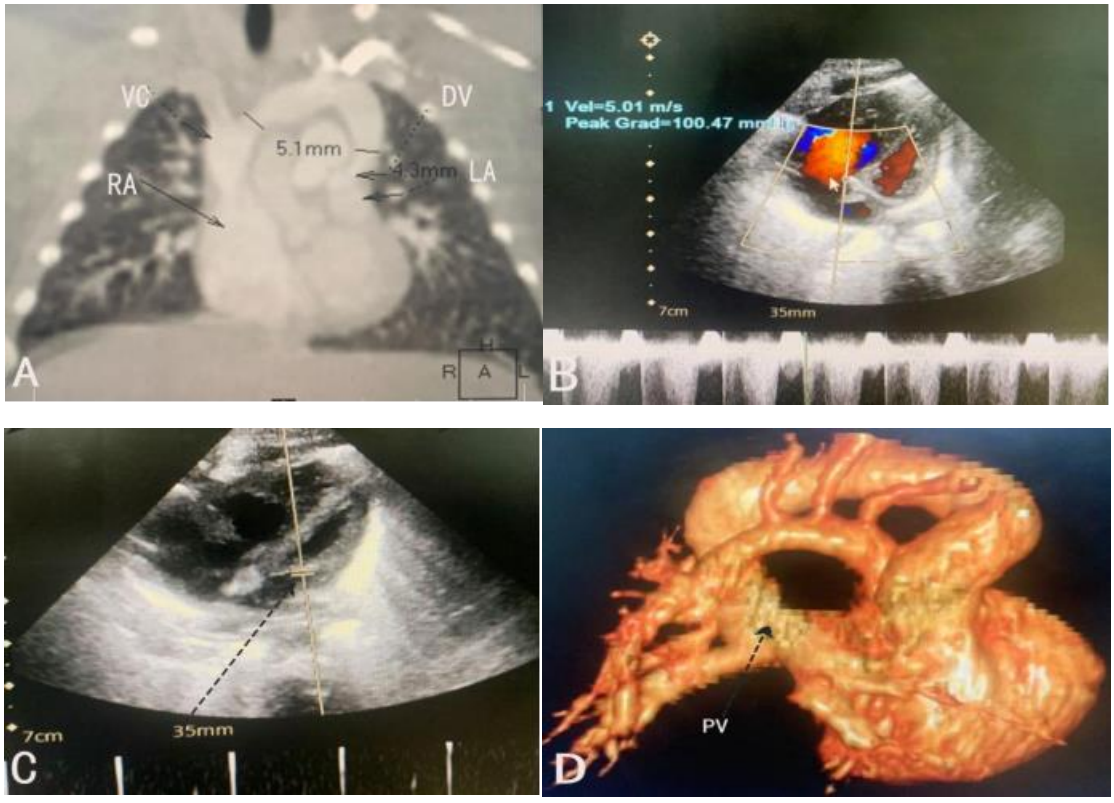
**Table 1:** Patient's age, chief complaint, preoperative imaging, and postoperative results.

| Age | Chief Complaint | Ultrasound Performance | CTA Performance | Results |
|---|---|---|---|---|
| 3days | Shortness of breath, foaming 1 hour | TAPVC (supracardiac type), combined with atrial septal defect | TAPVC (supracardiac type), combined with atrial septal defect and patent ductus arteriosus | Successful discharge |
| 52 days | Recurrent respiratory symptoms for 15 days | TAPVC (supracardiac type), combined with atrial septal defect and tricuspid regurgitation | TAPVC (supracardiac type), combined with an atrial septal defect | Successful discharge |
| 63 days | Shortness of breath for 20 days | TAPVC (supracardiac type), combined with patent ductus arteriosus, atrial septal defect and petant foramen ovale | TAPVC (supracardiac type), combined with patent ductus arteriosus and atrial septal defects | Successful discharge |
| 68 days | Shortness of breath for 13 days | TAPVC (supracardiac type), combined with an atrial septal defect | TAPVC (Supracardiac type), combined with an atrial septal defect | Successful discharge |
| 97 days | Episodes of recurrent respiratory infections for 27 days | TAPVC (supracardiac type), combined with atrial septal defect and patent foramen ovale | TAPVC (supracardiac type), combined with an atrial septal defect | Successful discharge |

**Figure 1:** supracardiac TAPVC imaging. 1A seen on preoperative CT, 1B and C seen on preoperative ultrasound, and 1D seen on preoperative CTA.



**Surgical method (supracardiac type)**

Each child was placed in a lying position, and after successful general anaesthesia, the left flexor artery and the right femoral vein of the child were routinely punctured. The surgical procedures were as follows: sterilisase the sheet, take the chest incision, cut the skin, subcutaneous tissue, saw the sternum in the middle, make "T" type incision of the pericardium and suspension, extracardiac exploration: the heart is enlarged, the right heart is mainly large, the pulmonary artery is thickened, the aorta: the pulmonary artery = 1:2, the left auricle can be seen behind the vertical vein converging into the innominate vein, and the thick arterial conduit converging into the main pulmonary artery. The pulmonary artery is thickened, aorta: pulmonary artery=1:2. Routine cannulation via the aorta and superior and inferior vena cava was performed to start extracorporeal circulation, and the arterial catheter was ligated under parallel circulation. When the temperature dropped to 32℃, the ascending aorta was blocked and the heart was stopped by direct perfusion of De1Nidio fluid via the aortic root. The vertical vein was freed and ligated, the main pulmonary vein was freed via the left atrial apex and then incised transversely to the right and left pulmonary vein bifurcations, and the right atrium was incised, and a central atrial defect was explored, measuring 0.5 cm in diameter, to widen the atrial septal defect. The left atrial roof was incised at the corresponding position of the main pulmonary vein incision, 7-0 prolene continuous suture of the main pulmonary vein and the left atrial roof incision, the upper edge of the incision was applied with autologous pericardium to expand the anastomosis, so as to establish the pulmonary vein-left atrial channel, and the corresponding large and small calf pericardial patch was clipped to expand the repair of the interatrial septal defect, and the last stitch was exhausted and tied with a knot in 6-0 prolene continuous suture. Ligate the vertical vein. The lungs were expanded and exhausted, and the ascending aorta was opened. The heart resumed beating automatically in sinus rhythm. Probe for atrial defect repair without residual leakage, tricuspid valve closure was possible, 6-0 prolene suture of the right atrium, the last stitch was tied after exhaustion. The patient was rewarmed to 36.3 degrees Celsius, the flow rate was gradually reduced, the body was stopped, a mediastinal drain was placed, the chest was closed layer by layer, the skin was sutured, and the child returned to the ICU.

## RESULTS

Surgery was successful in the 5 children, and all of them were discharged from the hospital after surgery. The duration of surgery varied from 150 to 500 min, the bleeding volume was in the 10-50 ml range, with an average of 30 ml, and the postoperative hospital stay varied from 31 to 43 days, with an average of 35 days. Postoperative hospitalisation duration ranged from 31 to 43 days, with an average of 35 days. The follow-up period ranged from 1 to 12 months, with an average of 6 months. Cardiac ultrasonography was respectively performed at 1 month and 3 months after the operation. In one case, the ultrasonography showed moderate mitral regurgitation at 3 months after the operation, while the other 4 cases recovered well after surgery and no abnormality was found in the repeat cardiac ultrasonography.

## DISCUSSION

TAPVC in infants is a complex congenital cardiovascular anomaly in which the pulmonary veins do not connect to the left atrium, but directly or indirectly converge to the right atrium, and blood flow from the left heart is shunted from the right atrium through the right-to-left shunt of atrial septum defect (ASD) or patent foramen ovale (PFO), which is detected in infants at 1 year of age. Mixed hypoxic blood flow from the right atrium enters the left cardiac circulation through the right and left atrial traffic ports causing cyanosis. At the same time, blood flow in the pulmonary circulation increases significantly. Once ectopic pulmonary venous reflux complicates obstruction, pulmonary congestion, bruising and pulmonary hypertension occur, while oxygenated pulmonary venous blood fails to enter the left atrium normally, the left heart lacks normal blood supply, the left cardiac circulation is insufficient, and the affected child has poor growth and development, with recurrent pneumonia and heart failure.

TAPVC accounts for approximately 2% of the incidence of congenital heart diseases Deng et al. (2018), Peirone et al. (2021), Zhang et al. (2020), Ding et al. (2017). Wilson et al. (1798) first reported the disease in 1798. Related literature reports Wen et al. (2020), Jiang et al. (2006), Zhu et al. (2022) that the disease is more frequent in males than in females. However, supracardiac is a relatively more frequent type of complete vena cava ectopic drainage in neonates. It is rare and severe, with a mortality rate of up to 48.8% in infancy without surgical intervention Elamry et al. (2019). Patients born without interatrial or interventricular traffic can be severely ill in infancy or even neonatally, with 80% dying within 1 year of age Zhu et al. (2022), thus requiring early surgical intervention. The etiological mechanism of this disease is currently unknown, and it may be related to the embryo in the process of congenital development, genetic mutation and pulmonary venous formation and differentiation disturbed by a variety of factors. When the common pulmonary venous trunk is underdeveloped, degenerated or atresia, the connection between the primitive pulmonary venous plexus and the visceral venous plexus remains, and may develop into TAPVC and PAPVC [partial TAPVC, PAPVC pulmonary venous connection, PAPVC].

According to its combination or lack of combination with other malformations, TAPVC is divided into two types: simple APVC, and compound APVC, while compound TAPVC is accompanied by other malformations, such as single atrium, single ventricle, and ventricular septal defect, etc. In 1957, Darling Craig et al. (1957) classified TAPVC into four types, supracardiac type 40%~50%: common pulmonary venous return to the superior vena cava; endocardiac type 20%~30%: common pulmonary venous return to coronary sinus or direct return to the right atrium; subcardiac type 10-30%: common pulmonary venous return to the portal vein, hepatic vein, venous conduit, or inferior vena cava; and mixed type 5-10% is a mixture of the above types. Supracardiac is subdivided into two types. Type I refers to the return of the common vein to the superior vena cava after draining into the left innominate vein and singular vein via the vertical vein, and this case belongs to Type I. Type II refers to the direct return to the superior vena cava. Supracardiac is the most commonly reported TAPVC type in the literature He et al. (2021), Cervantes-Salazar et al. (2022). TAPVC is also often combined with other cardiac malformations. Studies Liu et al. (2020), Weston et al. (1988) showed that 60 cases of neonatal TAPVC were combined with cardiac malformations other than atrioventricular shunt (14.2%), and ventricular septal defect, perpetual left superior vena cava, and aortic constriction were the most common. The main clinical manifestations of neonatal TAPVC are shortness of breath, cyanosis, recurrent respiratory infections and heart failure in children immediately after birth. Fetal echocardiography has become the predominant technique for prenatal diagnosis of APVC. Two-dimensional and colour Doppler flow imaging (CDFI) are the most important prenatal diagnostic methods for APVC. B-flow imaging (B-Flow) and high-definition flow imaging (HD-Flow) are complementary to 2D diagnostic techniques. Spatio-temporal image correlation (STIC) is a new technique for prenatal diagnosis of TAPVC, which uses sophisticated imaging technology to reconstruct the fetal heart in three dimensions. By showing structural abnormalities of the fetal heart in three dimensions, it allows for a clearer assessment of each pulmonary vein's course, drainage path, and location, further defining the TAPVC classification. Transthoracic echocardiography (TTE) is a non-invasive, inexpensive, and non-radioactive method for clinical diagnosis of congenital heart diseases. However, due to the influence of neonatal anatomy, developmental status and poor compliance, the diagnosis of TAPVC is often a difficult problem for echocardiography, with a high rate of misdiagnosis and underdiagnosis Sun et al. (2017). Current studies have shown that CT angiography (CTA) has a high diagnostic rate for neonatal TAPVC, which is superior to echocardiography Wang et al. (2018), Cong et al. (2017), but CTA is characterised by contrast allergy, potential radiological damage, and high price. Cardiac catheterisation and DSA examination can also be used for the diagnosis of neonatal TAPVC, but they are more traumatic to the patient and are rarely used in clinical practice.

Surgery is an inevitable choice for the treatment of neonatal TAPVC. Supracardiac TAPVC: The apical approach to the left atrium, i.e., the superior vena cava at the transverse sinus of the pericardium and the ascending aortic space, can be used to make a wide anastomosis between the pulmonary venous commissures and the left atrium. The atrial septal defect (ASD) or unclosed patent foramen ovale can be repaired with an enlarged patch through right atrial dissection, and vertical veins can be ligated after the stoppage of extracorporeal circulation. Alternatively, a posterior approach to the primary repair technique can be used Suarez et al. (2009), in which a modified sutureless anastomosis is constructed by suturing the left atrium to the posterior pericardium that surrounds the confluence of the pulmonary veins. This technique avoids trauma to the pulmonary vein walls and minimises the risk of anastomotic deformity, which are factors that are associated with the development of subsequent pulmonary vein obstruction. To prevent postoperative pulmonary vein obstruction, Wang et al. (2022) and other researchers described a window anastomosis technique for the repair of supracardiac TAPVC in infants. The main approach of the surgical technique is to resect the anterior wall of the pulmonary venous confluence and a portion of the posterior wall of the left atrium to form a large, undistorted "window-to-window" anastomosis.

Postoperative intensive care management of TAPVC is also a major challenge. All the 5 children developed different degrees of pulmonary hypertension and hypoxaemia after surgery, and our experience is to strictly control the fluid intake after surgery, keep the fluid intake and output in a negative balance for one week after surgery, and replenish the blood products and albumin during this period in light of the test results. Early application of drugs can be used to reduce pulmonary hypertension such as NO and targeted therapy drugs. Targeted therapies include 1. endothelin receptor antagonist ERA Gorenflo et al. (2021), 5-phosphate-dihydrogenase inhibitor PDE-5i, synthetic prostacyclin (PGI2) analogues, and prostacyclin (IP) receptor agonists. Initial targeted drug therapy is given as a two- or three-plex targeted drug therapy, with the two-plex regimen consisting of ERA in combination with PDE-5i, and the three-plex regimen consisting of ERA in combination with PDE-5i and prostacyclin (IP) agonists Chunlei et al. (2018), which is beneficial for the recovery of the child. These therapeutic measures or medications should be tapered after the child improves and should not be

discontinued immediately to prevent recurrence of pulmonary hypertension. Prevention of postoperative hepatic and renal dysfunction is the focus of treatment. In this study, 3 children developed transient hepatic and renal dysfunction after surgery, 1 developed persistent hepatic dysfunction, and 1 developed acute renal damage. Following the early application of hepatoprotective drugs and peritoneal dialysis according to their condition, the children improved and were finally discharged from the hospital in good health.

Lemaire et al. (2017) studied 180 children with TAPVC who were treated surgically from 1973 to 2014 and found that their overall mortality rate was 27.1%, with an early mortality rate of 21.1% and an intermediate and late mortality rate of 6.1%. Cui Hujun et al. (2016) reported that the overall mortality rate during the postoperative follow-up of 84 children with TAPVC who were treated surgically for less than 6 months from 2012 to 2015 was 11.9%. Guo Zhangke et al. (2021) found an overall postoperative mortality rate of 8.3% (21/253) in 255 children with TAPVC from 2009 to 2019, with an early mortality rate of 6.3% and an intermediate mortality rate of 2.1%. There are inconsistent results among studies regarding the risk factors for postoperative mortality in children with TAPVC. Some studies have shown Cui et al. (2016), Louis et al. (2012), Shi et al. (2017) that subcardiac and mixed types are independent risk factors for postoperative mortality in children with TAPVC. Some studies have also shown Hyde et al. (1999), Seale et al. (2010), Zhang et al. (2008), Zhang et al. (2016) that age less than or equal to 6 months with PVO is a risk factor for death.

## CONCLUSION

Neonatal TAPVC is a rare cyanotic congenital heart disease with poor natural prognosis and ineffective pharmacological treatment. Once diagnosed, patients must receive early surgical treatment. The surgical risk of neonatal TAPVC is high, and sudden death may occur both intraoperatively. Postoperative mortality of neonatal TAPVC is found to remain high at most international cardiac centres. Preoperatively, we determine the timing of surgery, intraoperative anaesthesia and surgical plan through multidisciplinary cooperation. Satisfactory surgical outcomes can be achieved through enhanced perioperative management, good myocardial protection, precise intraoperative anaesthesia management and surgical operation. Postoperative cardiopulmonary, hepatic, and renal protection, nutritional support, complication prevention, and appropriate anti-infective treatment were provided through multidisciplinary cooperation, and the children were discharged from hospital. PVO is a postoperative complication of neonatal TAPVC, and careful surgical operation and intensive care in paediatric cardiology can effectively prevent the occurrence of postoperative PVO and other serious complications. None of the 5 children in our study had PVO after surgical treatment, but they should be followed up for a long period of time. Once PVO is detected, it should be treated promptly. However, long-term follow-up is still needed to protect the children's life and health by timely treatment once they are detected with PVO.

## DECLARATIONS

### Contributors' Statement

Dr.YB, Dr. JZ and Dr. ZW conceived and designed the research, drafted the initial manuscript, Dr. LX reviewed and revised the manuscript , Dr.BF collected the data, performed a preliminary analysis. All authors have read and approved the manuscript.

### Availability of data and materials

All data generated or analyzed during this study are included in this article and its supplementary information files.

### Competing interests

The authors declare no competing interests.

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### Consent for publication

In this statement, written consent for the release of this information has been obtained from the parents of the study participant.

This study confirmed that informed consent was obtained from all subjects and/or their legal guardians.

### Ethical approval and consent to participate

The Institutional Review Board of Xi'an International Medical Center Hospital affiliated with Northwestern University approved this study.

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