

# Clinical Value of Echocardiographic Screening and Dynamic Observations for Ductus Arteriosus Closure in Newborns

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**Abstract:** *Objective:* To explore and analyze the clinical value of echocardiography screening and dynamic observation for ductus arteriosus closure in newborns. *Methods:* The study was conducted from August 2022 to December 2023. 500 newborns who were admitted to our hospital were selected as research subjects for this study (Kunming Tongren Hospital). All subjects underwent echocardiography to determine the severity of patent ductus arteriosus (PDA). The inner diameter of the pulmonary artery was measured, and the pulmonary artery pressure was estimated through tricuspid regurgitation. If the patient had high pulmonary artery pressure, elective closure surgery was performed. *Results:* Among the 500 subjects, 448 cases of ductus arteriosus closure and 52 cases of PDA were detected by echocardiography, including 23 cases of simple PDA, 15 cases with patent foramen ovale, 11 cases with atrial septal defect, 1 case with muscular ventricular septal defect, 1 case with tricuspid valve prolapse, and 1 case with tricuspid valve chordae tendineae rupture. After symptomatic treatment and intervention, their echocardiogram results were reviewed and no abnormalities were found. All measurement results of children with PDA combined with pulmonary hypertension were better than before treatment ( $P < 0.05$ ). *Conclusion:* Echocardiography is a fast, accurate, and reliable non-invasive imaging examination technology. It can significantly improve congenital heart disease detection rate in infants and young children. Early intervention based on the examination results can dramatically improve the quality of life of infants and young children with PDA.

**Keywords:** Infants and young children; Ductus arteriosus closure; Echocardiography

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## 1. Introduction

Patent ductus arteriosus (PDA) is a common congenital heart disease. It accounts for about 10–15% of congenital heart diseases. The incidence ratio between men and women is about 1:2. The disease can occur alone or be combined with other types of cardiovascular malformations, such as patent foramen ovale, atrial septal defect, atrial septal defect, pulmonary valve stenosis, aortic coarctation, and aortic valve stenosis <sup>[1,2]</sup>.

The chances of children surviving complex congenital heart disease, such as hypoplastic left heart syndrome, aortic arch disconnection, pulmonary atresia with intact ventricular septum, and complete transposition of the great arteries are closely related to PDA. Therefore early diagnosis is crucial and symptomatic treatment needs to be carried out promptly <sup>[3]</sup>. Echocardiography is a routine imaging examination technology for diagnosing various cardiac lesions. It is non-invasive, simple, and repeatable. Some medical institutions have applied it in PDA screening and achieved good results <sup>[4]</sup>. In this study, 500 newborns who were admitted to our hospital were selected as research subjects to explore and analyze the clinical value of echocardiography screening and dynamic observation of arterial duct closure.

## **2. Materials and methods**

### **2.1. General information**

This study was approved by our hospital's Medical Ethics Committee. The study was conducted from August 2022 to December 2023. The research subjects were 500 newborns admitted to our hospital, including 262 males and 238 females. Their gestational age was between 36-39 weeks, with an average of  $37.59 \pm 1.44$  weeks, and they were 3-7 days old, with an average of  $5.02 \pm 0.83$  days. All subjects had no contraindications for echocardiography. The parents of the subjects understood and consented to the study.

### **2.2. Methods**

All subjects underwent bedside echocardiographic examination using a Philips color Doppler ultrasound diagnostic instrument. A children's ultrasound probe with a frequency of 3-8 MHz was used. The procedure of the examination is as follows: (1) The subjects lied down on their left side in a prone position. An ultrasound probe was used to scan the long axis of the parasternal left ventricle. Relevant parameters and cardiac function were measured, and the probe was rotated to scan the parasternal right ventricular inflow tract section and parasternal large axis. The main pulmonary trunk and left and right pulmonary arteries were observed through the short-axis section of blood vessels, and the inner diameter of the main pulmonary artery was measured. (2) The infants were observed for PDA through the pipe connecting the descending aorta and pulmonary artery. The color blood flow imaging mode was initiated to check for the presence of a shunt within the lumen of the ductus arteriosus. If a shunt was identified, the direction of the shunt was observed, and the shunt speed and pressure difference were measured. (3) The apical four-chamber view of the subjects was examined, with a specific focus on observing the blood flow jet of tricuspid valve regurgitation. The ultrasound probe angle was adjusted to maintain a parallel alignment between the regurgitant blood flow jet and the ultrasound beam. The tricuspid regurgitation peak flow velocity and pressure difference were then measured. If pulmonary valve stenosis or right ventricular outflow tract stenosis were absent, the right ventricular systolic pressure and the pulmonary artery systolic pressure would be the same. Otherwise, the pulmonary artery systolic pressure would be higher than the right ventricular systolic pressure. The degree of tricuspid regurgitation was mainly determined by the regurgitation speed of the tricuspid valve and the length of the regurgitant jet. When the regurgitant jet reached the lower 1/4 area of the right atrium, it was regarded as trace reflux; when the regurgitant jet reached 1/2 of the right atrium, it was regarded as minor reflux; when the regurgitant jet reached 3/4 of the right atrium, it was considered to be moderate regurgitation; when the regurgitant jet reached the entire right atrium, it was massive reflux. (4) Subjects who were diagnosed with PDA through ultrasonography received symptomatic treatment and intervention, and subjects with PDA combined with pulmonary hypertension underwent elective closure surgery.

### 2.3. Evaluation criteria

The echocardiographic examination results of 500 newborns were compiled and analyzed, and the ultrasound of subjects with PDA before and after treatment was compared and analyzed.

### 2.4. Statistical methods

The data were analyzed using SPSS 23.0 software. The measurement data were expressed as mean  $\pm$  standard deviation and compared using *t*-tests, while the count data were expressed as percentages (%) and compared through a  $\chi^2$  test;  $P < 0.05$  indicated statistical difference.

## 3. Result

### 3.1. Echocardiographic examination

Among the 500 newborns who underwent echocardiography, 448 cases had closure of the arterial ductus, with no abnormal blood flow communication between the aorta and pulmonary artery. However, in 52 newborns abnormal blood flow communication was observed between the aorta and pulmonary artery. In these cases, the predominant observation was a mainly red blood flow signal shunted to the pulmonary artery through the descending aorta. Doppler imaging revealed a continuous spectrum of red blood flow from left to right, indicating a split flow. Notably, the split flow exhibited relatively high velocities, with peak flow velocities reaching 4-5 m/s.

Among the 52 children with PDA, 23 had simple PDA, and 22 had pulmonary hypertension. According to the PDA morphological classification standards, 50 had the ductal type, 1 had the funnel type, and 1 had the window type.

### 3.2. Comparative analysis of various ultrasound results in newborns with PDA before and after treatment

Children with PDA combined with pulmonary hypertension underwent elective closure surgery. The remaining children received drug treatment or no symptomatic intervention. Echocardiograms were reviewed at 6-month intervals. The results showed that the sign of abnormal blood flow between the aorta and pulmonary artery disappeared. After treatment, the ultrasound results of children with PDA combined with pulmonary hypertension were significantly improved ( $P > 0.05$ )

**Table 1.** Comparative analysis of ultrasound results in newborns with PDA before and after treatment (mean standard deviation)

Group	The inner diameter of the main pulmonary artery (mm)	Right inner diameter (mm)	Right atrial diameter (mm)	Pulmonary artery pressure (mmHg)
Before treatment ( $n = 22$ )	9.68 $\pm$ 1.53	13.82 $\pm$ 1.75	14.27 $\pm$ 1.96	47.85 $\pm$ 3.59
After treatment ( $n = 22$ )	7.46 $\pm$ 0.75	10.54 $\pm$ 0.98	11.72 $\pm$ 1.13	22.96 $\pm$ 1.44
<i>t</i> -value	6.111	7.670	5.287	30.182
<i>P</i> -value	0.000	0.000	0.000	0.000

## 4. Discussion

The ductus arteriosus is a muscular arterial structure evolved from the sixth arch artery tissue in the fetal stage. The upper-end area is connected to the isthmus or distal end of the aortic arch, the lower-end area is

connected to the left pulmonary artery tissue, and a few are connected to the bifurcation area of the left and right pulmonary arteries<sup>[5,6]</sup>. The dynamic duct is a physiological channel connecting the pulmonary artery and the aorta in the fetal blood circulation system. The pulmonary circulation resistance decreases significantly after the birth of the fetus. Most blood in the right ventricle flows directly into the pulmonary vascular tissue, and the blood flow into the descending aorta through the ductus arteriosus significantly reduces<sup>[7]</sup>. The ductus arteriosus of most newborns closes on the 3rd day after birth and eventually evolves into the arterial ligament. However, some infants still have ductus arteriosus that is not closed within 1 year after birth, leading to abnormal blood flow communication between the aorta and pulmonary artery. This type of disease is clinically classified as pediatric PDA<sup>[8]</sup>.

PDA is a common type of congenital heart disease, accounting for approximately 10–15% of all types of congenital heart disease. It can occur alone or be combined with other cardiovascular malformations. Failure to diagnose and treat early may affect the quality of children's lives. The gold standard for clinical diagnosis of PDA is right heart catheterization technology. Nevertheless, this procedure is invasive and needs to be done repeatedly, so it is not ideal for infants and young children<sup>[9]</sup>. Echocardiography is a commonly used imaging technology for diagnosing various heart diseases. It is simple, non-invasive, repeatable, and has high resolution. The heart's structure and blood flow conditions can be visualized through two-dimensional ultrasound and color Doppler ultrasound, which allows accurate diagnoses of various heart diseases<sup>[10]</sup>. In recent years, prenatal fetal ultrasound screening has become increasingly popular, the diagnostic skills of sonographers have gradually improved, and the number of children born with complex congenital heart disease has significantly decreased. Most public tertiary hospitals in provincial capital cities have implemented neonatal echocardiography, which can enable early detection and treatment of complex congenital heart disease. However, some newborns cannot undergo echocardiography due to various reasons, leading to delays in treating pulmonary hypertension<sup>[11]</sup>. Therefore, medical institutions and parents need to fully understand the significance of echocardiography in screening for arterial duct closure in newborns. Parents need to ensure that their child receives echocardiography examinations as early as possible so that symptomatic treatment and intervention can be performed if abnormalities are found.

This study showed that among the 500 newborns who underwent echocardiography, 448 cases had closed ductus arteriosus and 52 had PDA. The main ultrasound signs were abnormal blood flow communication between the aorta and pulmonary artery, characterized by predominantly red blood flow. This flow was redirected to the pulmonary artery through the descending aorta, creating a continuous left-to-right shunt in the spectrum. Echocardiography involves two-dimensional ultrasonic examination and color Doppler ultrasonic examination, which enables the detection of abnormalities in cardiac structure and blood flow conditions. The closure of the ductus arteriosus can be confirmed by observing and analyzing the blood flow signal between the aorta and pulmonary artery. This diagnostic approach also allows for the assessment of pulmonary hypertension. Additionally, echocardiography serves as a valuable tool in checking for any associated cardiac structural and functional abnormalities in children with PDA. This comprehensive evaluation provides essential information for guiding the treatment of related diseases<sup>[12,13]</sup>. The results of this study showed that the abnormal blood flow traffic signals between the aorta and pulmonary arteries of newborns with PDA disappeared in 6 months. Besides, the ultrasound results of children with PDA combined with pulmonary hypertension improved after treatment. Most children with PDA can achieve closure of the ductus arteriosus through continuous monitoring or drug treatment. The condition of children with PDA combined with pulmonary hypertension is relatively complex. Therefore, it is necessary to measure the tricuspid regurgitation status through echocardiography to determine the presence of pulmonary hypertension. For children with PDA combined with severe pulmonary

hypertension, it becomes necessary to intervene by blocking the left-to-right shunt through occlusion surgery or other methods. This intervention is particularly crucial when the pulmonary blood vessels have not undergone restructuring, or the degree of remodeling is minimal. The objective is to decrease pulmonary artery blood flow and alleviate pulmonary artery pressure. This approach can control the progression of the disease and significantly improve the quality of life of infants and young children<sup>[14,15]</sup>. We believe that echocardiography screening and arterial observation of arterial ductus closure in infants and young children have outstanding clinical value and should be promoted in clinical practice. It is essential for doctors to be skilled in the post-examination process, ensuring standardized examination procedures and clear identification of key points for diagnosing PDA and other cardiac lesions. For children diagnosed with PDA, regular reviews of echocardiograms are necessary to accurately assess the effectiveness of their treatment.

## 5. Conclusion

Echocardiography is a non-invasive imaging examination technology with the advantages of accuracy, speed, and reliability. It can significantly improve congenital heart disease detection rate in infants and young children. Early intervention based on the examination results can dramatically improve the quality of life of infants and young children. However, the sample size of this study was small, and there was no cross-sectional comparison of multiple centers. Therefore, in-depth research is still required for issues related to echocardiographic screening of arterial duct closure in infants and young children.

## Disclosure statement

The authors declare no conflict of interest.

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