

The Impact of Fetal Echocardiography on Outcome of Patients with Pulmonary Atresia with Ductal-dependent Pulmonary Flow

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Objective: Pulmonary atresia is a relative rare critical congenital heart defect with ductal dependent pulmonary circulation. Echocardiography is the gold standard in diagnoses congenital heart defect in newborns, but also is the only diagnostic modality of congenital heart defect in the fetus. The purpose of this study is to demonstrate the impact of fetal echocardiography on outcome of patients with pulmonary atresia with ductal-dependent pulmonary flow.

Methods: A single-institution observational study was made on 19 children diagnosed by echocardiography with ductal-dependent pulmonary atresia in Pediatric Cardiology Department from 1997 to 2010, from which four were diagnosed prenatally by fetal echocardiography. We compared a series of clinical data between the prenatally (group 1) and postnatally diagnosed group (group 2), respectively.

Results: All of the infants diagnosed prenatally were delivered in a center for pediatric cardiology. The prostaglandine infusion, to maintain the patency of arterial duct, was initiated in the first 48 h after birth in every cases of the first group comparing to the second group (range 3 h – 37 days) (26.66%) ($p=0.03$). Also, a significantly higher percent of group 1 managed to get in the cardiac unit in the first 48 h after birth comparing to the second group (range 1–37 days) ($p=0.03$).

Conclusions: We suggest that fetal diagnosis might improve neonatal outcome because of earlier appropriate therapeutic intervention.

Keywords: pulmonary atresia, ductal-dependent, fetal echocardiography, outcome

Introduction

Pulmonary atresia is a relatively rare critical congenital heart defect with ductal dependent pulmonary circulation, in which the pulmonary flow for further oxygenation is supplied by the systemic circulation through the patent ductus arteriosus. Pulmonary atresia can be present as pulmonary atresia with intact ventricular septum (occurring in 7.1–8.1 per every 100,000 live births and in 0.7–3.1% of patients with congenital heart disease), as extreme form of tetralogy of Fallot (occurs in 2.5–3.4% of all congenital cardiac malformations), or as any complex congenital heart defect with pulmonary atresia [1].

The fetus with such congenital heart defects develops normally intrauterine because of the existence of intracardiac shunts at two important levels: ductus arteriosus and interatrial septum. These patients usually cannot tolerate the transition from fetal to postnatal circulation after birth, their postnatal survival depending on the persistence of ductus arteriosus [1]. The major clinical finding in these patients soon after birth is cyanosis, indicated by decreased oxygen saturation, with rapid deterioration of the babies condition without proper management.

If not diagnosed early in life, many of these defects may result in life-threatening events or significant morbidity [2]. With early diagnosis, however, most infants with congenital heart defect can benefit from successful surgical repair or palliation [3].

Echocardiography is the gold standard in the diagnosis of congenital heart defects in newborns, but also is the only diagnostic modality of congenital heart defects in the fetus.

Fetal echocardiography has been shown to be an accurate technique [4]. Progresses achieved in the domain of echocardiography allow early determination of heart malformation diagnosis, as early as the first 20 weeks of intrauterine life [5].

The purpose of this study is to demonstrate if prenatal detection of a critical congenital heart defect such as pulmonary atresia with ductal-dependent pulmonary circulation influences the postnatal outcome of these patients. To our knowledge, this is the first such study in Romania.

Methods

A single-institution observational study has been carried out on 19 children diagnosed with ductal-dependent pulmonary atresia born all over the country and admitted to the Institute of Cardiovascular Diseases of Tîrgu Mureş between 2007 and 2010. At the Department of Pediatric Cardiology all patients underwent a complete postnatal echocardiographic (for cardiac diagnoses) and physical examination (including pulse-oximetry). Echocardiography was performed using an IE33 Philips echocardiograph. Among the 19 patients diagnosed with pulmonary atresia, 6 had pulmonary atresia with intact ventricular septum, 1 had pulmonary atresia with tricuspid atresia, 1 pulmonary atresia with Ebstein anomaly, in 3 cases we found an extreme form of tetralogy of Fallot (associated with pulmonary atresia), while in 2 cases we found double outlet right ventricle with pulmonary atresia and in 6 cases pulmonary atresia was part of a complex congenital heart defect (Table I).

All cases were congenital heart defects with ductal-dependent pulmonary flow, and received prostaglandine 1

Table I. Distribution of patients by diagnosis in the two groups

Diagnosis	Group 1 Prenatal Dg	Group 2 Postnatal Dg
Pulmonary atresia with intact ventricular septum	3	3
Pulmonary atresia with tricuspid atresia	1	–
Pulmonary atresia with Ebstein anomaly	–	1
Tetralogy of Fallot associated with pulmonary atresia	–	3
Double outlet right ventricle with pulmonary atresia	–	2
Complex CHD with pulmonary atresia	–	6

infusion to maintain the patency of ductus arteriosus until surgery. All patients benefited of surgical intervention: in 18 cases a systemic to pulmonary shunt was performed, and in 1 case a surgical transannular patch with a systemic-to-pulmonary artery shunt. One patient died during surgery.

In all patients we evaluated the following data: gestational age at birth, birth weight, Apgar score at birth, place of delivery, time to diagnosis, oxygen saturation, time to prostaglandine E1 treatment initiation, time to transfer to a cardiac unit, hypoxic complications and time to surgery.

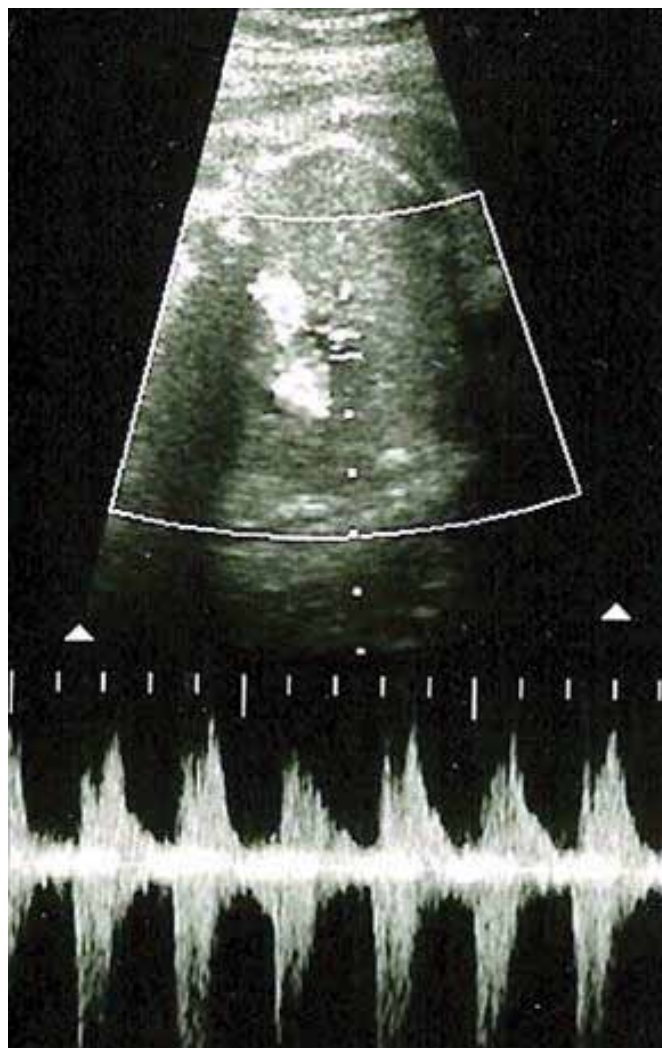


Fig. 1. Pulse Doppler interrogation of the main pulmonary artery – demonstrates the absence of forward flow across the pulmonary valve and retrograde flow in the arterial duct

Table II. Clinical data evaluated in the two groups

Diagnosis	Group 1 Prenatal Dg Mean±SD or % n=4	Group 2 Postnatal Dg Mean±SD or % n=15	p
Gestational age	38.66±0.57	39.33±0.57	0.18
Born in a center for pediatric cardiology	4 (100%)	9 (60%)	0.35
Birth weight	3575±436.8	2717.5±274.2	0.007
Apgar score at birth	8.42±0.53	7.25±2.21	0.19
Time to diagnosis ≤48 h	iu (100%)	4 (26.66%)	0.03
SaO ₂ at the moment of Prostyn initiation <80%	0	11(73.33%)	0.03
Time to transfer to a cardiac unit ≤48 h	4 (100%)	4 (26.66%)	0.03
Time to start of prostaglandin infusion ≤48 h	4(100%)	4(26.66%)	0.03
Hypoxic complications	0	3(20%)	0.83
Time to surgery	21.75±7.27	29.75±14.77	0.51

In 4 patients the diagnosis was established prenatally by fetal echocardiography (bidimensional and Doppler) after arising the suspicion of a cardiac lesion by an obstetrician. The scanning of the fetal heart was carried out using the following protocol [6,7,8]:

1. Initial step – establish laterality: heart position, apex position, stomach position;
2. Establish direction of the cardiac axis;
3. 4-chamber view: used for evaluation of cardiac chambers and intracardiac septums. Pulmonary atresia with intact ventricular septum and complex cardiac defects with pulmonary atresia are associated with abnormal 4-chamber view;
4. Extended views (including demonstration of outflow tract), the 3-vessel view used for identification of the aorta and pulmonary origins, identification of characteristics of normal great arteries: one arising from each ventricle; the arteries cross each other soon after leaving the heart; the pulmonary arteria divides into 3 (each branch and the ductus). Extreme form of tetralogy of Fallot and double outlet right ventricle with pulmonary atresia can be detected using extended views.

Ultrasound features in pulmonary atresia are: 4-chamber view of the heart will appear abnormal with a small right ventricle, the pulmonary valve appears as a solid bar of mobile tissue, the pulmonary artery may appear relatively normal or may be small and hard to identify, Doppler will demonstrate the absence of forward flow across the valve and retrograde flow in the arterial duct (Figure 1), moderate-to-severe high velocity tricuspid regurgitation, and the coronary sinusoids may be seen with colour Doppler [6].

The legal guardians of the enlisted patients signed a consent form in conformity with the norms of the Ethical Committee of the University of Medicine and Pharmacy from Tîrgu Mureş.

Statistical analysis

Categorical data were compared with the use of Pearson's

2 test with Yates' correction as appropriate when expected values were small. The t-test for independent samples was used to compare parameters between two groups. Values of $p < 0.05$ were considered statistically significant. All statistical analyses were performed with STATISTICA software.

Results

Among the 19 patients, 4 (21%) were diagnosed prenatally with fetal echocardiography (group 1). The diagnoses were confirmed by postnatal echocardiography. In 15 cases (78.9%) the diagnosis was established postnatally (group 2), as shown in Table II.

Infants were born at comparable gestational age, irrespective of whether fetal diagnosis had been made (mean [SD] 38.6 [0.57] weeks vs. 39.33 [0.57] for infants with or without a fetal diagnosis, respectively, $p=0.18$).

Four (100%) of the live-born infants with a prenatal diagnosis were delivered in a center for pediatric cardiology. Among infants without a fetal diagnosis, only 60% were born in a center for pediatric cardiology ($p=0.35$).

In patients without a prenatal diagnosis, recognition of cyanotic heart disease was usually delayed, just 33.33% of cases being correctly diagnosed within 48 h after birth. Also, the prostaglandine infusion was initiated in the first 48 h after birth in every case of the first group, compared to the second group (range 3h–37 days) (26.66%) ($p=0.03$).

The oxygen saturation level was less than 80% before starting the prostaglandine infusion, in 73.33% from the postnatally diagnosed group ($p=0.03$).

We also studied the percentage of patients transferred to the cardiac unit within the first 48 h after birth, and we found a significantly higher percentage in group 1 managed (range 1–37 days) ($p=0.03$).

Neurological complications secondary to prolonged hypoxia occurred in 20% of the infants without fetal diagnosis (group 2), but in none of the patients with fetal diagnosis ($p=0.83$).

We also studied the time to surgery in infants with or without a fetal diagnosis. Although surgical intervention was performed earlier in group 1, no significant differences were observed between the two groups (mean [SD] 21.57 [7.27] days vs 29.75 [14.77] for infants with or without a fetal diagnosis respectively ($p=0.51$)).

Discussion

An increasing experience with fetal cardiac scanning by obstetric ultrasonographers may increase the frequency of antenatal diagnosis of congenital heart defects [9,10]. Yet, Cuneo *et al.* demonstrate in a study that collaboration between the obstetrician and the pediatric cardiologist can significantly improve the rate of detected critical congenital heart defects [11,12]. So, fetal echocardiography is a reliable tool for prenatal diagnosis in experienced hands [13,14]. However, the cost of a universal echocardiography screening program is estimated to be prohibitively high [15]. In our study, fetal echocardiography was carried

out in a collaboration between obstetrician and pediatric cardiologist.

In the present study, we tried to demonstrate the impact of prenatal detection of pulmonary atresia with ductal-dependent pulmonary circulation on the postnatal outcome, in comparison with those diagnosed postnatally.

First of all, we analyzed the relationship between place of delivery and the moment of diagnosis. Our data suggest that prenatal scanning has clearly affected the choice of hospital for delivery. All infants diagnosed prenatally were born in referral centers for pediatric cardiology, compared with just 60% of those diagnosed postnatally. There are some studies that assesses the outcome for live-born infants with congenital heart defects with and without a fetal diagnosis. Daubeney *et al.* demonstrated that among infants with pulmonary atresia and intact ventricular septum without a fetal diagnosis, significantly less infants were born in, or nearby, a center for pediatric cardiology [10,16].

Our findings suggest that infants with a prenatal diagnosis received the prostaglandin E1 infusion significantly earlier, before closure of the arterial duct. Also, significantly more patients were transferred into a cardiac unit within 48 h after birth in the prenatally diagnosed group. These data suggest that prenatal diagnosis allows a better management for these congenital heart defects.

Oxygen saturation is a sensitive marker of the balance between the systemic and pulmonary flow. When these two are equal, the SaO_2 is about 80%. Some authors demonstrated that early pulse-oximetry screening promotes early detection of critical congenital heart defects [17,18]. Others revealed that pulse oxymetry screening is not sensitive enough to serve as an independent screen, but along with the clinical examination it helps to minimise morbidity and mortality [19]. In this study we found no patient with SaO_2 lower than 80% before the prostaglandine infusion was started in the prenatally diagnosed group. Some studies sustain our findings [2]. This finding suggests that prenatal diagnosis may allow admission for surgery in a more stable condition, and it may be associated with lower short-term and long-term morbidity and mortality.

Another, less tangible benefit of prenatal diagnosis is that it may allow parents to "prepare" themselves psychologically. On the other hand, some studies evaluate the impact of fetal echocardiography on the incidence of critical congenital heart defects at birth. For the 5 years of the study, termination of pregnancy in mainland Britain resulted in a decrease in incidence of pulmonary atresia with intact ventricular septum at birth of 26% [3,20]. Shinebourne *et al.* reported in a series of prenatally diagnosed pulmonary atresia with intact ventricular septum, a high percentage (61%) of termination of pregnancy [21].

To our knowledge, this is the first study which evaluates the impact of fetal echocardiography on the outcome of patients with critical CHD, such as pulmonary atresia with ductal-dependent pulmonary flow. The number of patients

in this study was relatively small, but encourages us for further studies.

Conclusions

In conclusion, we anticipate that fetal diagnosis might improve neonatal outcome in patients with pulmonary atresia because of earlier appropriate therapeutic intervention. We can also conclude that a multidisciplinary approach is needed to the parental counseling and perinatal management planning.

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