Original **paper**

RETROSPECTIVE ANALYSIS OF PRETERM NEONATES WITH CONGENITAL HEART DEFECTS DELIVERED BY CESAREAN SECTION: UNFAVOURABLE OUTCOMES A NECESSITY FOR FETAL CARDIOLOGY EDUCATION DURING OBSTETRICAL TRAINING?

Authors:
Iwona Strzelecka[1], Maciej Słodki[2,3], Katarzyna Zych-Krekora[2], Michał Krekora[4], Mariusz Grzesiak[4], Iwona Maroszyńska[5], Maria Respondek-Liberska[1,2]

1. Department of Prophylaxis and Diagnosis of Congenital Diseases, Medical University of Lodz, Poland 2. Department of Prenatal Cardiology, Polish Mother's Memorial Hospital, Lodz, Poland 3. Faculty of Health Sciences. The State University of Applied Sciences in Plock 4. Poland.Department of Obstetrics and Gynecology, Polish Mother's Memorial Hospital, Lodz, Poland 5. Department of Intensive Care and Congenital Malformations of Newborns and Infants, Polish Mother's Memorial Hospital, Lodz, Poland

Prenat Cardio 2017 Jan; 7(1):50-57
DOI: 10.1515/pcard-2017-0008

Abstract

Introduction: Congenital heart defects are the most frequent reason for deaths during the neonatal and early infancy periods. The aim of this study was to retrospectively analyze singleton pregnancy outcomes of premature neonates with congenital cardiac defects delivered by Cesarean section.

Materials and methods: A retrospective analysis was performed on 10,800 fetuses evaluated in our referral fetal cardiac center between 2010 and 2016. A group of 58 singleton pregnancies was selected with the following criteria: fetal heart defect, Cesarean section (C-section), and gestation of 37 weeks or less. Exclusion criteria included labor outside of our hospital and multiple pregnancy.

Results: Isolated heart defects constituted 74,1% (43 cases) of the analysed data set. The majority of newborns were delivered at 36 weeks of gestation (43,1%), with an average of 33,6 weeks. In one case (1,7%), C-section took place at 22nd week. Birth weight of newborns < 2500g constituted 51,7% (30 cases). Neonatal deaths occurred in 60,3% (35 cases).

Conclusions: Preterm neonates with congenital heart defect, delivered by C-section in our reference centre, during 2010 to 2016, had generally poor outcomes and high mortality rate. The average hospital stay of surviving neonates was approximately two months. An improvement of knowledge about prenatal cardiology is necessary in obstetrician management with fetuses with congenital heart diseases.

Key words: *fetal heart defect, premature delivery, Cesarean section, low birth weigh*

INTRODUCTION

The development of diagnostic imaging techniques has improved the detection of congenital heart defects - the most common fetal defects. Congenital heart defects are the most frequent reason for deaths during the neonatal and early infancy periods.[1] Appropriate prenatal diagnostics means also increased control over the gravida and occasional detection of additional signs may lead to premature delivery and low birth weight neonates.

The aim of this study was to retrospectively analyze singleton pregnancy outcomes of premature neonates with congenital cardiac defects delivered by Cesarean section (C-section) to draw attention to the high mortality and need to prolong the gestation of fetuses with prenatally diagnosed heart defects.

How to cite this article:
Strzelecka I, Słodki M, Zych-Krekora K, Krekora M, Grzesiak M, Maroszyńska I, Respondek-Liberska M. Retrospective analysis of preterm neonates with congenital heart defects delivered by cesarean section: unfavourable outcomes a necessity for fetal cardiology education during obstetrical training? Prenat Cardio 2017 Jan; 7(1):50-57

MATERIALS AND METHODS

Retrospective analysis of 10 800 fetuses evaluated in the Department of Prenatal Cardiology, of our Institute in Łódź between 2010 and 2016, has shown 1745 fetuses (16%) with heart defects (Figure 1). From the overall population, a test group was selected according to the following criteria: fetal heart defect, preterm birth by C-section, < 37 weeks of gestation and singleton pregnancy. Exclusion criteria included labour outside of our institute and multiple pregnancy.

A group of 58 gravidas and 58 fetuses and 58 newborns was selected for analysis. Their medical records were analysed taking into account the age of the pregnant woman, type of pregnancy, type of fetal heart defect, gender of fetus, week of gestation at delivery, birth weight of neonate,

Corresponding author: majkares@uni.lodz.pl

Submitted: 2017-10-08, accepted: 2017-12-15

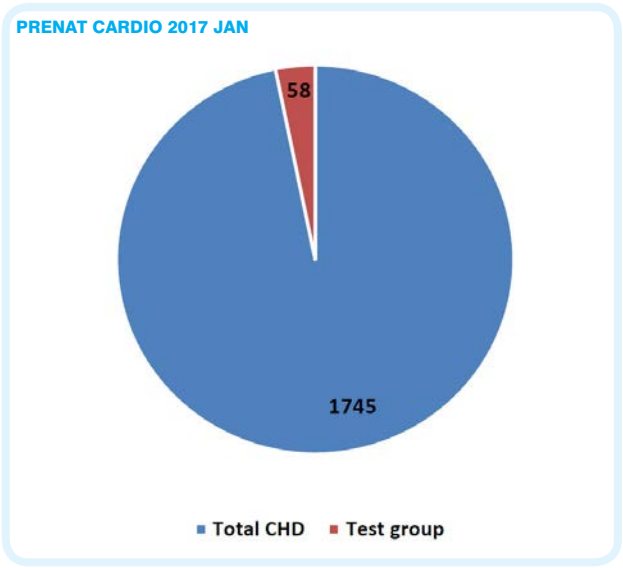

Fig. 1. Research in the Department of Prenatal Cardiology of ICZMP between 2010 and 2016.

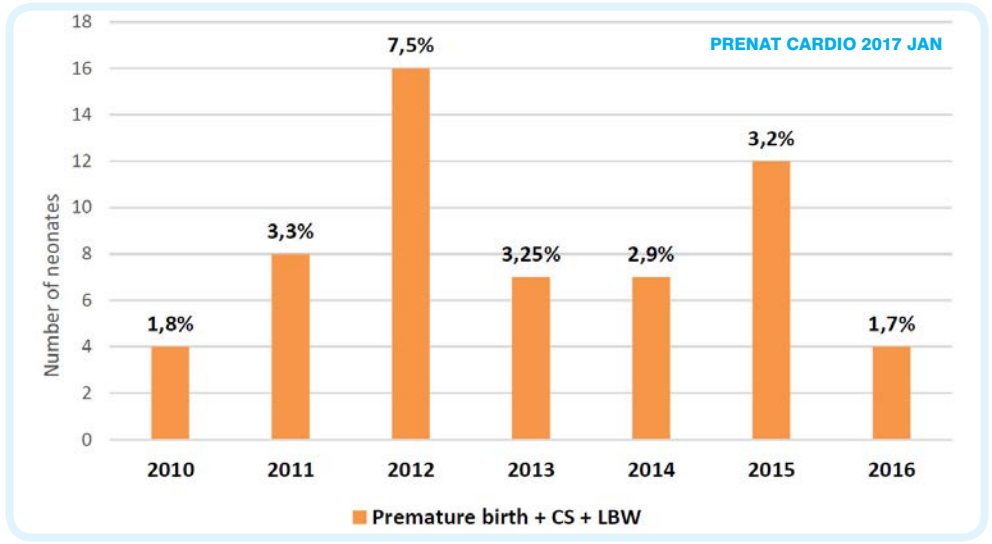

Fig. 2. Percentage of the test group in the population of neonates with a prenatally detected heart defect in the Department of Prenatal Cardiology of ICZMP in the years 2010-2016. (The vertical axis indicate number of neonates)

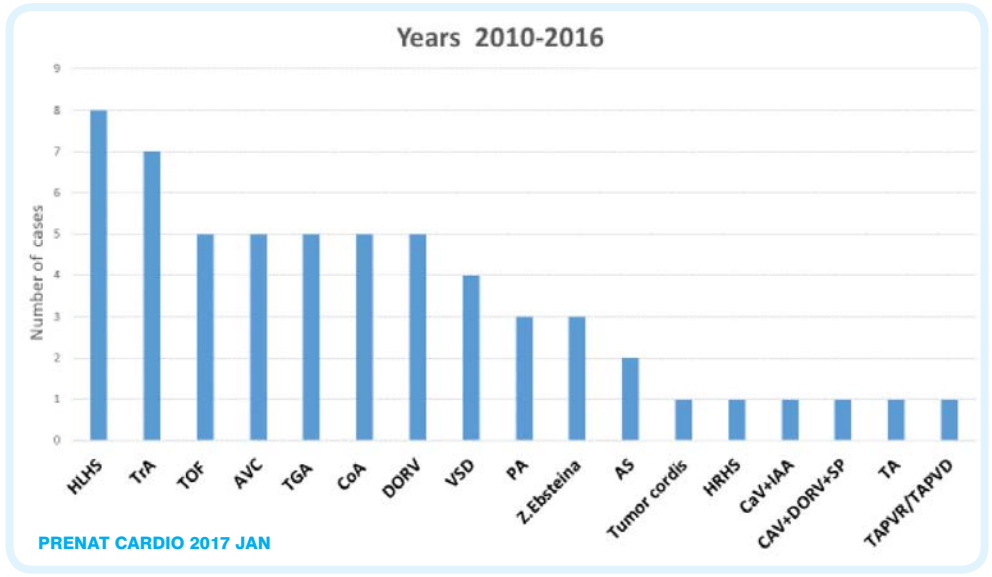

Fig.3. Types of CHD in the study group (n=58). (The vertical axis indicate the number of cases)

Apgar score and neonatal outcome. Table 1 shows the types of congenital heart defects (CHD), including the extra-cardiac malformations and surgical procedures in the newborns. Table 2 presents the same material but from the point of view of current classification of CHD and suggested postnatal management.

RESULTS

Fetal heart defects were most frequently diagnosed in the third trimester. Isolated heart defects constituted 74% of the analysed material (43 cases). The test group was dominated by the following fetal heart defects: hypoplastic left heart syndrome (HLHS, n=8), truncus arteriosus (TrA, n=7), atrioventricular canal (AVC, n=5), tetralogy of Fallot (TOF, n=5) and complex defects, such as common atrioventricular canal (CAV) with double outlet right ventricle (DORV) and pulmonary stenosis (PS), transposition of the great arteries (TGA) with DORV, TGA with PS and ventricular septal defect (VSD), aortic coarctation (CoA) with VSD, and DORV with VSD. The most rarely diagnosed were hypoplastic right heart syndrome (HRHS), total anomalous pulmonary venous return (TAPVR) and total anomalous pulmonary venous drainage (TAPVD) (Figure 3). A single case of heart tumor was included, in a neonate weighing 770 g (non-survivor) (Table 1).

Premature delivery after prenatal cardiac diagnosis (n=58) from 2010 to 2016 was on average 1,7–3,3% of patients with heart defects per year. Only in 2012, the incidence was 7,5% (n=16) in our centre (Figure 2). In the analysed material, high-risk pregnancies were the most common as a result of obstetrical anamnesis – 18 x (51,4%), the age of the gravida – 14 x (40%), or the disease of the gravida – 3 x (8,6%). Of the 58 pregnant women, 43 (74%) were under the age of 35 years.

The majority of the newborns were male (74,1%), delivered at 36 weeks of gestation (43,1%). In 1 case (1,7%) the C-section took place at 22 weeks. The average onset of labour was at 33,6 weeks

Type of heart defect	Number of cases	Birth weight (g)	Deaths n=35		Survivals n=23		Surgery n=11	
			CHD	ECM	CHD	ECM	Cardiac	Other
HLHS	7	2500	1	0	0	0	1	0
		2500	1	0	0	0	0	0
		2500	1	0	0	0	0	0
		2260	1	0	0	0	0	0
		1815	1	0	0	0	0	0
		980	1	Anal atresia	0	0	0	0
		350	1	0	0	0	0	0
HLHS VSD+Dekstroposition	1	1950	1	*Diaphragmatic hernia	0	0	0	0
AVC	5	2650	0	0	1	*Down S	0	0
		2400	0	0	1	*Down S	0	0
		2400	0	0	1	0	0	0
		2310	0	0	1	0	0	0
		2150	0	0	1	Hydronephrosis	0	0
TrA+VSD	5	1900	0	0	1	0	0	0
		1600	0	0	1	0	0	0
		2500	0	0	1	*Thymus hypoplasia	0	1
		2060	1	*Hydrocephalus	0	0	0	0
		1770	0	0	1	*Agenesis Corpus Callosum	1	0
TrA+MAPCA	1	1800	1	0	0	0	0	0
TrA+SV	1	2130	1	0	0	0	0	0
TOF, Pulm.valve atresia+RAA	1	1950	1	0	0	0	0	0
TOF	3	2000	0	0	1	*Atresia oesophagi	0	1
		1990	0	0	1	0	0	0
		1095	0	0	1	0	0	0
TOF+DORV	1	1980	1	0	0	0	0	0
d-TGA	2	2360	0	0	1	0	1	0
		2000	1	0	0	0	0	0
VSD	4	2000	1	0		0	0	0
		1850	0	0	1	0	0	0
		980	0	0	1	0	0	0
		920	0	0	1	0	0	0
DORV	2	1420	1	*Esophageal, Duodenal, Anal atresia	0	0	0	1
		430	1	*Agenesis of vermis cerebellum	0	0	0	0
DORV+TGA	1	2360	0	0	1	0	0	0

Table 1. Analysis of 58 preterm neonates with prenatally diagnosed congenital heart defects delivered by C-section at the ICZMP between 2010 and 2016. (part 1/2)

Type of heart defect	Number of cases	Birth weight (g)	Deaths n=35		Survivals n=23		Surgery n=11	
			CHD	ECM	CHD	ECM	Cardiac	Other
PA	2	2100	1	*Bowel hyperechogenic. Skelet malform.	0	0	0	0
		1410	0	0	1	*Omphalocele	0	1
PA. Tricuspid valve atresia	1	2450	0	0	1	0	1	0
HRHS	1	1055	1	0	0	0	0	0
Ebstein S.	3	2520 2500	3	0 *Esophageal atresia, Cleft palate	0	0	0	0
Tricuspid valve atresia	1	2550	1	0	0	0	0	0
Complex CHD:								
DORV+MV atresia	1	2300	1	0	0	0	0	0
CAV+IAA Dexcardia+Situs inversus	1	1900	1	0	0	0	1	0
CAV+DORV+PS Dexcardia, Situs solitus Heterotaxia	1	2300	1	0	0	0	0	0
DORV/TGA +PS	1	2240	1	0	0	0	0	0
TAPVR/TAPVD	1	1400	1	0	0	0	0	0
TGA in complex heart defects: (TGA+DORV)	1	2360	0	0	1	0	0	0
TGA+PS+VSD	1	2520	1	0	0	0	0	0
(TGA. Obs.ad Pulm.valve stenosis)	1	2320	1	0	0	0	1	0
CoA	2	1990	0	0	1	0	0	0
		1440	0	0	1	0	0	0
CoA+VSD	2	2500	1	0	0	0	0	0
		900	1	0	0	0	0	0
CoA+SV	1	2160	0	0	1	*Ileus	0	1
AS	2	1920	1	0	0	0	0	0
		1790	1	0	0	0	0	0
Tumor cordis	1	770	1	0	0	0	0	0
Total	**58**		**35**	**7**	**23**	**8**	**6**	**5**

HLHS – Hypoplastic Left Heart Syndrome / VSD – Ventricular Septal Defect / AVC – Atrioventricular Canal / PA – Pulmonary atresia / TrA –Truncus Arteriosus / MAPCA – Major Aorto-Pulmonary Collateral Arteries / TOF – Tetralogy of Fallot / SV – Single Ventricle / DORV – Double Outlet Right Ventricle / MV – Mitral Valve / TGA – Transposition of the Great Arteries / HRHS – Hypoplastic Right Heart Syndrome / CAV – Common Atrioventricular Canal / IAA – Interrupted Aortic Arch / PS – Pulmonary Stenosis / TAPVR – Total Anomalous Pulmonary Venous Return / TAPVD – Total Anomalous Pulmonary Venous Drainage / CoA – Aortic Coarctation / AS – Aortic Stenosis

Table 1. Analysis of 58 preterm neonates with prenatally diagnosed congenital heart defects delivered by C-section at the ICZMP between 2010 and 2016. (part 2/2)

(median, 35,0 ± 3,03 weeks (Figure 4). On average, cardiac surgery was performed on day 21 (median, day 16 ±*17,9*) after delivery. Thirty newborns (51,7%) had birth weight between 1500-2500g; 6 neonates weighed 1000-1500g, five neonates were 500-1000g and two were <500 g. The average birth weight was 1891g (median, 2000 ±586,2) (Figure 5).

The average Apgar score was 5,8 (median, 6 ± 2,6). Six newborns (10,4%) were given 1 point directly after birth. Fig. 6 presents the neonatal period analysis (n=58) including deaths, survivals, time of surgery, average hospital stay (in days), and day of hospital discharge. Neonatal deaths involved 35 cases (60,3%); 30 of these patients died before surgery and five after surgery. On average, surgery was performed on day 13 (median, day15 ± 9,35). The

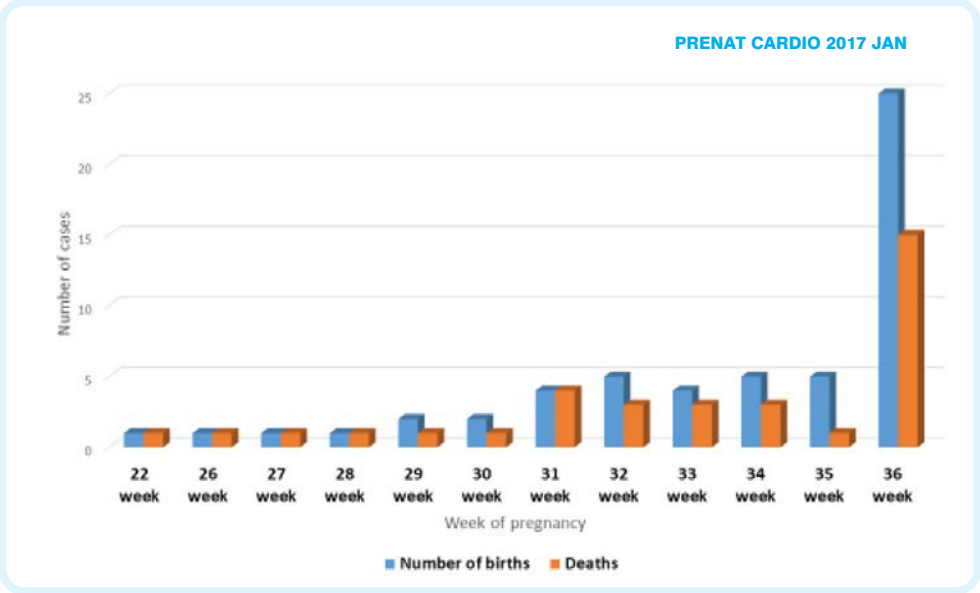

Fig. 4. The outcome of 58 premature neonates with congenital heart defects delivered by Cesarean section (35 deaths).

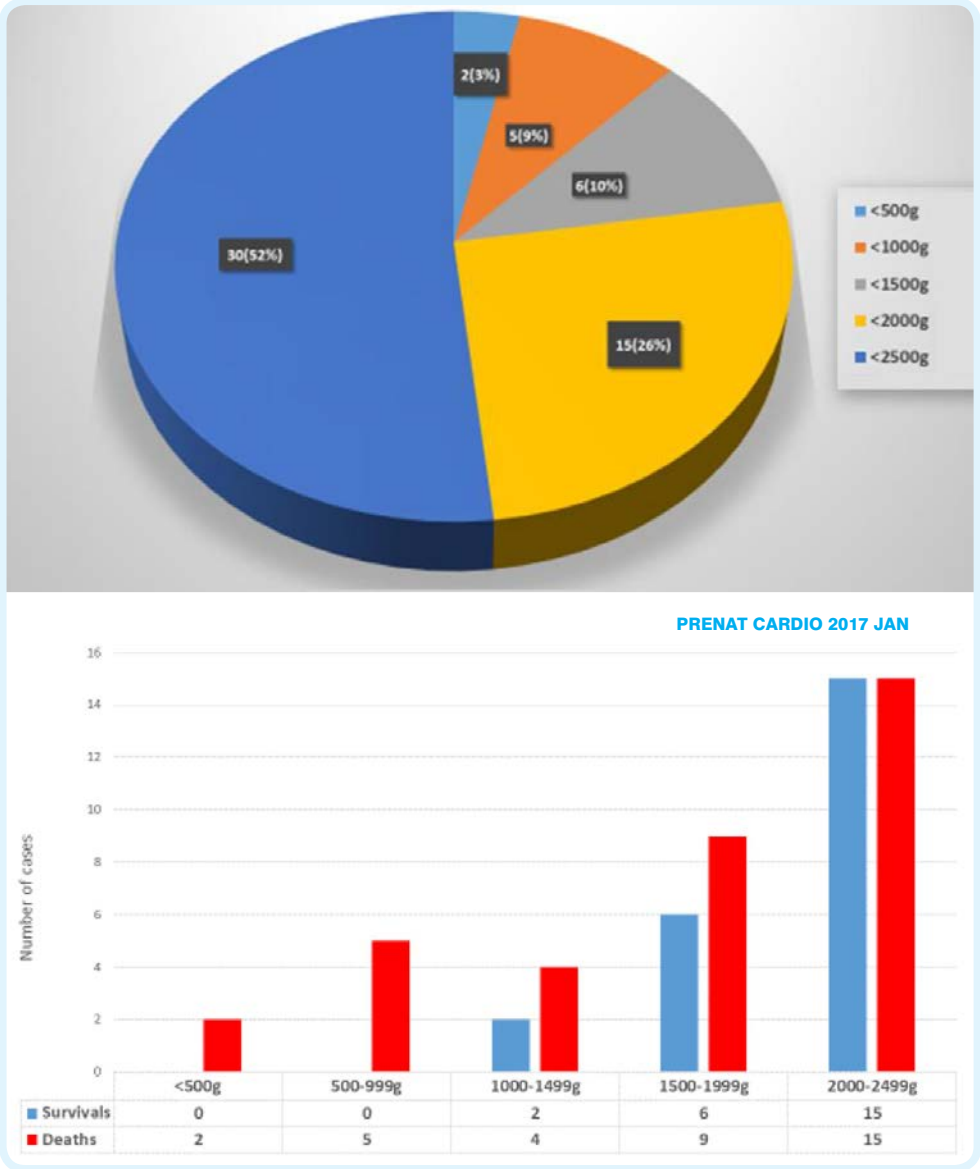

Figure 5. Birth weight of neonates in the analyzed population of 58 premature newborns with CHD after C-section.

average time of death was on day 16,4 (median, day 22 ± 13). Survivors constituted 39,7% of the study group (23 cases), 17 of whom did not require surgery. Six neonates underwent surgery on day 27. The average hospital stay of newborns with surgery was 62 ± 38 days and 43,3 ± 41,5 days for newborns without surgery.

There were two cases of the most severe heart defects (3,5%), eight cases (14%) of critical defects, 14 cases (24,5%) of planned severe defects, 18 cases (31,6%) of planned defects, nine cases (15,8%) of heart defects with concomitant extracardiac malformations (ECM), and six cases (10,6%) with concomitant extracardiac anomalies. In this classification, the single case with heart tumour was not taken under consideration. The group with the most severe and critical heart defects was marked by 100% of premature deaths of newborns. In the group with planned severe defects, 11 neonates died (78,6%). In the group with planned defects, there were 6 (33,4%) deaths. In the CHD + ECM group, there were five deaths (55,5%), and in the CHD + ECA group, there were two deaths (33,4%). Three newborns with urgent planned defects survived (21,4%). In the group of severe non-urgent defects, 12 survived (66,6%), while in both the CHD + ECM and CHD + ECA groups, four survived.

DISCUSSION

Fetuses with heart defects delivered prematurely by C-section compromise only a small proportion of all labors in our institute: less than 3% per year, but it seems to be extremely important because

of the high death rate – up to 60%. In the literature to date, attempts have been made by other groups to analyse premature and low birth weight neonates with fetal heart defects[2-8]. Andrews and co-workers, who demonstrated increased mortality among premature newborns with prenatally diagnosed heart defects, emphasized the importance of decisions over elective preterm delivery[4]. Van Velzen and colleagues confirmed that higher percentage of premature deliveries and neonatal deaths occurred among fetuses with isolated heart defects[2]. And Miyoshi and co-workers described the impact of low birth weight neonates with prenatally diagnosed heart defects on

CHD according to prenatal cardiology	Anatomical CHD	Deaths	Experience	Operation	Days of the newborns hospital stay before going home
The most faults		26			
Most severe	TAPVR/TAPVD – 1400g	1	0	0	-
	Cardiomegaly+CoA+VSD – 900g	1	0	0	-
Critical	HLHS – 350g	1	0	0	-
	HLHS + FO restr. – 1815g	1	0	0	-
	HRHS – 1055g	1	0	0	-
	Ebstein S.+ PS – 610g	1	0	0	-
	Ebstein S.+ PS – 2520g	1	0	0	-
	TGA +PS+FO restr.– 2360g	1	0	1	-
	AS – 1790g	1	0	0	-
	AS – 1920g	1	0	0	-
Planned severe defects for prostin alnd planned cardiac surgery	HLHS – 2500g	1	0	1	-
	HLHS – 2260g	1	0	0	-
	HLHS – 2500g	1	0	0	-
	HLHS – 2500g	1	0	0	-
	TOF. Pulm.valve atresia. Aortic arch.right – 1950g	1	0	0	-
	PA. Tricuspid valve, other anom. – 2450g	0	1	1	34
	Tricuspid valve atresia – 2550g	1	0	0	-
	CAV+IAA Dextrocardia, Situs inversus – 1900g	1	0	0	-
	CAV+DORV+PS Dextrocardia, Situs solitus. Heterotaxia – 2300g	1	0	0	-
	TGA – 2360g	0	1	1	27
	TGA – 2000g	1	0	0	-
	TGA – 2000g	0	1	0	78
	TGA+PS+VSD – 2520g	1	0	0	-
	CoA +VSD – 2500g	1	0	0	-
Planned defects	AVC – 2150g	0	1	0	31
	AVC – 2400 g	0	1	0	7
	TrA – 1600g	0	1	0	31
	TrA – 1900 g	0	1	0	28
	Tra + MAPCA – 1800g	1	0	0	-
	TrA + SV – 2130g	1	0	0	-
	TOF – 1095g	0	1	0	96
	TOF – 1990g	0	1	0	160
	TOF – 2000g	1	0	0	-
	TOF +DORV+VSD – 1980g	1	0	0	-
	VSD – 980g	1	0	0	-
	VSD – 1850g	0	1	0	23
	VSD – 2000g	0	1	0	30
	VSD – 920g	0	1	0	61
	DORV – 2360g	0	1	0	200
	DORV – 2300g	1	0	0	-
	CoA – 1450g	0	1	0	37
	CoA – 1990g	0	1	0	10

Table 2. The classification of heart defects in the analyzed material according to prenatal cardiology[10,11] (part 1/2)

CHD according to prenatal cardiology	Anatomical CHD	Deaths	Experience	Operation	Days of the newborns hospital stay before going home
CHD + ECM	HLHS – 980g + Anal atresia	1	0	0	-
	HLHS – 1950g + DH	1	0	0	-
	PA – 1410g + Omphalocele	0	1	1	90
	AVC – 2310g + Hydronephrosis	0	1	1	52
	DORV+VSD – 1420g + Esophageal atresia, Duodenal atresia, Anal atresia	1	0	1	-
	Ebstein S. – 2500g + Esophageal atresia, Cleft palate	1	0	0	-
	CoA+SV – 2160g + Ileus	0	1	1	30
	TOF – 2000g+ Atresia oesophagi	0	1	1	120
	TrA – 2060g + Hydrocephalus	1	0	1	-
CHD+ECA	PA – 2100g + Bowel hyperechogenic. Skelet malform. (Polidactylia)	1	0	0	-
	AVC - 2650g + DS	0	1	0	20
	AVC – 2400g + DS	0	1	0	6
	TrA + VSD+ACC – 1770g	0	1	1	71
	TrA – 2500g + Thymus hypoplasia	0	1	0	7
	DORV+VSD – 430g + Agenesis of vermis cerebellum	1	0	0	-
Total	n=57*	34	23	11	

Note! The case with tumor cordis is not presented in the table.

Table 2. The classification of heart defects in the analyzed material according to prenatal cardiology[10,11] (part 2/2)

the number of emergency surgical labors[5]. Based on studies from 2007 to 2014, it was concluded that fetal echocardiography and cardiovascular profile score should be taken under consideration when planning the type of labour and perinatal care in the above-mentioned group.

The prenatal detection of fetal heart defects and their subsequent diagnosis play a vital role in perinatal care. The fates of the youngest patients with heart defects depend on the effectiveness of prenatal cardiologists and the close cooperation with obstetricians. In the test group of 58 newborns with heart defects delivered by C-section at < 37 weeks of gestation, the majority (43 neonates) were given more Apgar scores of > 5, while 15% were below this score, suggesting that fetal distress and possible death before labour pertained to the minority. Still, 60% (n=35) of newborns died and most of them (30 neonates) did not undergo surgery. It is not altogether clear if these cases did not qualify for surgical procedures because of the nature of their cardiac defects or if surgical interventions were not implemented in time.

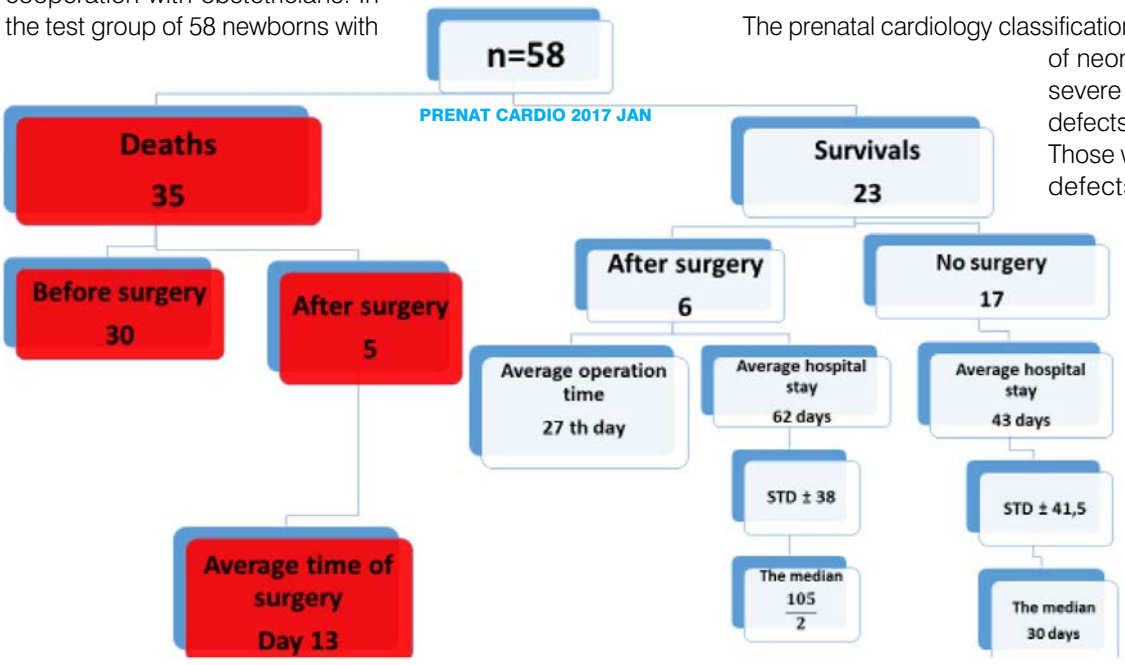

Fig. 6. Postnatal period of the study group (n=58).

The prenatal cardiology classification showed that 100% of neonates with the most severe and critical cardiac defects did not survive[10,11]. Those with planned severe defects and prematurity rarely survive while planned defects survive more often, but with a long hospital stay for cardiac or extracardiac anomalies and due to prematurity (Table 2). In the group with planned severe defects, 11 neonates died

(78,6%). In the group with planned defects, there were 6 (33,4%) deaths comparing to the newborns delivered in term it was much more higher, planned severe defects - 25% and planned defects 3% respectively.[11]

Surgical treatment was implemented in 11 cases (19%): HLHS (1 case), TGA (2), TrA (2), PA (2), TOF (1), CoA (1), CaV+IAA (1), and DORV (1). Six of 11 (55%) had an isolated heart defect. Of the 23 newborns who survived, 6 were operated on (26%) with the following defects: TGA, TOF, TrA, CoA, PA). Four had: concomitant extracardiac malformations, intestinal obstruction, diaphragmatic hernia, omphalocele and oesophageal atresia. It is a especially difficult group of patients and the fact that they were rescued means that there was a very good cooperation between neonatologists, paediatric cardiologists, paediatric surgeons and anaestheologists.

Better detection of heart defects and improvements in prenatal cardiac diagnostics entail improved knowledge of prenatal cardiology principles among members of the perinatology team. The majority of prenatal heart defects are clinically silent, without symptoms of decompensation from fetal circulatory system and most of these neonates may be delivered with the desired birth weight and on time. Despite significant progress in neonatology, cardiology and paediatric cardiac surgery, we should realize that in the current organizational and financial situation and the Polish National Health Fund (NFZ) delivery of premature newborns with a heart defect reduce their chances of survival (in our study 60% mortality).

If a fetal heart defect is detected, obstetricians, who supervise pregnancies and who have some knowledge of fetal cardiology, probably can improve the survival rates of the youngest and most clinically challenging fetuses and neonates with heart defects by extending the duration of pregnancy, instead of shortening its natural time length by premature C-section. Future studies on outcomes of newborns with prenatal diagnosis of heart defects, born after 37 weeks of gestation during the same time period of 2010 to 2016 and at the same centre, may be instructive.

CONCLUSIONS

The delivery of premature neonates with congenital heart defects and low birth weight (<2500g) in our reference centre between 2010 and 2016 resulted in a high percentage of deaths (60%).

An average hospital stay of patients who survived lasted about 2 months (including a stay in the Intensive Care Unit, postoperative care or intermediate care), which involved high costs.

Improved knowledge of prenatal cardiology among obstetricians might contribute to more effective efforts to prevent preterm delivery of fetuses with heart defects.

References

1. *Słodki M, Zych-Krekora K, Axt-Fliedner R, Bianchi A, Araujo E Jr, Blickstein I, Kelekci S, Yeo L, Pruetz JD, Rizzo G, Seligman N, Sklansky M, Catte L, Weiner S, Chervenak F, Cruz J, Kurkevych A, Krekora M, Respondek-Liberska M. The International Prenatal Cardiology Collaboration Group – a new concept for global research study. J Ultrasonog. 2016; 16: 94-96.*
2. *Van Velzen CL, Türkeri F, Pajkrt E, Clur SA, Rijlaarsdam ME, Bax CJ, Hruda J, de Groot CJ, Blom NA, Haak MC. Pregnancy complications in singleton pregnancies with isolated fetal heart defects. Acta Obstet Gynecol Scand. 2016; 95: 1273-1280.*
3. *Nembhard WN, Salemi JL, Hauser KW, Kornosky JL. Are there ethnic disparities in risk of preterm birth among infants born with congenital heart defects? Birth Defects Res A Clin Mol Teratol. 2007; 79: 754-764.*
4. *Andrews RE, Simpson JM, Sharland GK, Sullivan ID, Yates RW. Outcome after preterm delivery of infants antenatally diagnosed with congenital heart disease. J Pediatr. 2006; 148: 213-216.*
5. *Miyoshi T, Katsuragi S, Neki R, Kurosaki KI, Shiraishi I, Nakai M, Nishimura K, Yoshimatsu J, Ikeda T. Cardiovascular profile score as a predictor of acute intrapartum non-reassuring fetal status in infants with congenital heart defects. J Matern Fetal Neonatal Med. 2016; 14: 1-7.*
6. *Story L, Pasupathy D, Sankaran S, Sharland G, Kyle P. Influence of birth weight on perinatal outcome in fetuses with antenatal diagnosis of congenital heart disease. J Obstet Gynaecol Res. 2015; 41: 896-903.*
7. *Anagnostou K, Messenger L, Yates R, Kelsall W. Outcome of infants with prenatally diagnosed congenital heart disease delivered outside specialist paediatric cardiac centres. Arch Dis Child Fetal Neonatal Ed. 2013; 98 : F218-F21.*
8. *Changlani TD, Jose A, Sudhakar A, Rojal R, Kunjikutty R, Vaidyanathan B. Outcomes of infants with prenatally diagnosed congenital heart disease delivered in a tertiary-care pediatric cardiac facility. Indian Pediatr. 2015; 52: 852-856.*
9. *Strzelecka I, Płużanska J, Węgrzynowski J, Moszura T, Słodki M, Respondek-Liberska M. Routine third trimester fetal cardiac evaluation: time for consideration. Prenat Cardiol. 2015: 5: 18-23.*
10. *Słodki M, Respondek-Liberska M, Pruetz JD, Donofrio MT. Fetal cardiology: changing the definition of critical heart disease in the newborn. J Perinatol. 2016; 36: 575-580.*
11. *Słodki M. Habilitation Thesis. Medical University Lodz, PWSZ Plock: Poland,2012, https://www.researchgate.net/publication/291337775_Prenatal_and_perinatal_management_for_pregnant_women_with_fetal_cardiac_defects_based_on_new_prenatal_cardiac_anomalies_classification_Polish.*

Acknowledegement

The authors would like to thank prof. R. Yanagihara from University of Honolulu for valuable comments in the article.

Division of work:

Iwona Strzelecka - first draft of the manuscript, analyzes of the data

Maciej Słodki - analyzes of the data, work with the manuscript

Katarzyna Zych-Krekora - work with the manuscript

Michał Krekora - work with the manuscript

Mariusz Grzesiak - work with the manuscript

Iwona Maroszyńska - work with the manuscript

Maria Respondek-Liberska - concept of the research, analyzes of the data, work with the manuscript, final version

Conflict of interest: The authors declare no conflict of interest

The work is financed by the Lodz Medical Research no. 503 / 8-144-08 / 503-81-004