

Percutaneous interventions in patients with hypoplastic left heart syndrome after stage first Norwood operation

Zabiegi kardiologii interwencyjnej u pacjentów z zespołem hipoplazji lewego serca po pierwszym etapie leczenia metodą Norwooda

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Abstract

Background: Hypoplastic left heart syndrome (HLHS) still remains a therapeutic challenge due to complex anatomical and haemodynamic abnormalities. The multistage treatment leads to consequences and complications limiting the efficacy of surgery and necessitating additional percutaneous interventions.

Aim: To evaluate the type of necessary percutaneous interventions in patients after stage first Norwood operation for HLHS with a focus on different techniques and equipment and to determine the efficacy of interventional treatment.

Material and methods: Between 2001 and 2010 we conducted 161 interventions in 88 patients with HLHS at all stages of palliation. We performed 47 interventions in 38 patients after stage first Norwood operation. The main reasons for percutaneous treatment in this group were as follows: stenosis of the aortic arch/isthmus (20 patients), stenosis of the Sano shunt (8), proximal pulmonary arteries stenosis (6) and secondary restriction of the atrial communication (4).

Results: In the group of 20 infants with stenosis of the aortic arch/isthmus balloon angioplasty allowed widening of the stenosis from 2.87 ± 0.82 mm to 5.15 ± 0.82 mm ($p < 0.05$) and a decrease of the systolic pressure gradient between the aortic arch and the descending aorta from 29.38 ± 15.40 mmHg to 7.14 ± 4.28 mmHg ($p < 0.05$). In 1 patient a stent was implanted due to rapid recurrence of the stenosis. In the group of 8 patients with critical stenosis of the right ventricle to pulmonary artery shunt successful interventions were done in 7 infants (87%). In 5 cases (62%) percutaneous balloon angioplasty turned out to be a sufficient treatment. Two patients (25%) required implantation of a stent to the Sano shunt. Oxygen saturation increased from $52 \pm 12\%$ to $75 \pm 4\%$ ($p = 0.002$) and the diameter of the stenosis increased from 2.28 ± 0.48 mm to 4.14 ± 0.69 mm ($p = 0.0025$). Six patients after stage first of the surgical palliation required balloon angioplasty of the tight proximal pulmonary artery stenosis. The diameter of the stenosis increased from 2.33 ± 0.51 mm to 3.58 ± 0.49 mm ($p = 0.0099$); however, the decrease of the pressure gradient from 3.33 ± 1.63 mmHg to 2.5 ± 1.05 mmHg was statistically insignificant. Secondary restriction of the atrial communication was successfully treated in all 4 patients. The diameter of the connection increased from 4.2 ± 1.15 mm to 9.9 ± 3.17 mm ($p = 0.0079$) and left atrial pressure decreased from 19.4 ± 4.1 mmHg to 13.8 ± 2.4 mmHg ($p = 0.0075$). In half of the patients it was sufficient to perform static atrioseptostomy whereas the second half required stent implantation.

Conclusions: Percutaneous interventions lead to haemodynamic stabilization prior to the next step of treatment, increase arterial oxygen saturation and decrease pulmonary arterial pressure, therefore lowering the number of required operations. Rescue interventions such as stenting of the interatrial septum or critically stenosed Sano shunt should be considered in deteriorating patients even despite the risk of complications.

Key words: hypoplastic left heart syndrome, interventional treatment

Streszczenie

Wstęp: Zespół niedorozwoju lewego serca (*hypoplastic left heart syndrome* – HLHS) ze względu na złożony charakter nieprawidłowości anatomicznych i hemodynamicznych stanowi nadal trudny problem terapeutyczny. W procesie wieloetapowego leczenia

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wciąż występują określone następstwa i powikłania, które zmniejszają skuteczność leczenia operacyjnego i zmuszają do wykonywania dodatkowych zabiegów interwencyjnych.

Cel: Ocena charakteru niezbędnych zabiegów interwencyjnych u pacjentów z HLHS po pierwszym etapie leczenia metodą Norwooda, z uwzględnieniem różnych technik i rodzaju sprzętu oraz określenie skuteczności kardiologicznego leczenia interwencyjnego.

Materiał i metody: W latach 1999–2010 w Pracowni Hemodynamiki Kliniki Kardiologii Instytutu Centrum Zdrowia Matki Polki w Łodzi wykonano 161 procedur kardiologii interwencyjnej u 88 dzieci z HLHS na poszczególnych etapach leczenia. U 38 pacjentów po pierwszym etapie wykonanym metodą Norwooda przeprowadzono 47 interwencji przezskórnych. Głównym problemem w tej grupie było zwężenie łuku lub cieśni aorty (20 pacjentów), zwężenie zespolenia komorowo-płucnego (8), zwężenie proksymalnej gałęzi płucnych (6) oraz wtórna restrykcja na połączeniu międzyprzedsionkowym (4).

Wyniki: W grupie 20 dzieci ze zwężeniem łuku lub cieśni aorty przezskórne zabiegi angioplastyki balonowej pozwoliły na poszerzenie zwężenia z wyjściowo $2,87 \pm 0,82$ mm do $5,15 \pm 0,82$ mm ($p < 0,00001$), z obniżeniem gradientu ciśnienia skurczowego z $29,38 \pm 15,40$ mmHg do $7,14 \pm 4,28$ mmHg ($p = 0,00006$) oraz ciśnienia skurczowego powyżej zwężenia z $86,52 \pm 16,44$ mmHg do $81,38 \pm 15,65$ mmHg ($p = 0,0367$). U 7 (87%) z grupy 8 dzieci z ciasnym zwężeniem zespolenia komorowo-płucnego wykonano skuteczne zabiegi interwencyjne. W 5 przypadkach (62%) wystarczało przeprowadzenie przezskórnej angioplastyki balonowej, w 2 przypadkach (25%) implantowano stenty wewnątrznaczyniowe do zespolenia Sano. Uzyskano wzrost saturacji tlenem krwi tętnicznej po zabiegu z $52 \pm 12\%$ do $75 \pm 4\%$ ($p = 0,002$) oraz wzrost średnicy zwężenia z $2,28 \pm 0,48$ mm do $4,14 \pm 0,69$ mm ($p = 0,0025$). U 6 dzieci wykonano angioplastykę proksymalnego zwężenia gałęzi płucnych. Uzyskano poszerzenie zwężenia z $2,33 \pm 0,51$ mm do $3,58 \pm 0,49$ mm ($p = 0,0099$) oraz nieistotne statystycznie ($p = 0,1851$) zmniejszenie bezpośredniego gradientu ciśnienia skurczowego przez zwężenie z $3,33 \pm 1,63$ mmHg do $2,5 \pm 1,05$ mmHg. Wtórna restrykcja połączenia międzyprzedsionkowego była wskazaniem do interwencji u 4 dzieci. U wszystkich pacjentów uzyskano skuteczne powiększenie połączenia międzyprzedsionkowego z $4,2 \pm 1,15$ mm do $9,9 \pm 3,17$ mm ($p = 0,0079$), z obniżeniem ciśnienia w lewym przedsionku z $19,4 \pm 4,1$ mmHg do $13,8 \pm 2,4$ mmHg ($p = 0,0075$). W połowie przypadków wystarczające były zabiegi przezskórnej atrioseptomii statycznej, u pozostałej dwójki dzieci implantowano stent do przegrody międzyprzedsionkowej.

Wnioski: Przezskórne interwencje u pacjentów z HLHS po operacji sposobem Norwooda pozwalają na stabilizację stanu hemodynamicznego przed kolejnymi etapami leczenia, a w rezultacie redukcję liczby zabiegów chirurgicznych. Prezentowane nietypowe, ratunkowe zabiegi kardiologii interwencyjnej, takie jak stentowanie przegrody międzyprzedsionkowej czy krytycznie zwężonego zespolenia Sano, pomimo ryzyka powikłań, powinny być brane pod uwagę, gdy stan dziecka jest ciężki, a potencjalne korzyści z zabiegu są wymierne.

Słowa kluczowe: zespół hipoplazji lewego serca, leczenie interwencyjne

Introduction

Hypoplastic left heart syndrome (HLHS) remains a therapeutic challenge due to the complex character of anatomical and haemodynamic abnormalities. The progress in surgical treatment of congenital heart diseases which took place in the last decade significantly improved prognosis of children with HLHS. Nevertheless, multistage treatment still leads to certain consequences and complications limiting the efficacy of surgical procedures and requiring additional percutaneous interventions. The main problems include stenosis of the aortic arch/isthmus, stenosis of the right ventricle to pulmonary artery shunt or pulmonary arteries as well as primary and secondary restriction of the interatrial communication. Currently used, modern methods of interventional treatment support and partially replace the surgical procedures. These procedures may be successfully used before, during and after each stage of treatment in patients with HLHS.

Aim

The aim of the study was to evaluate the type of the required percutaneous interventions in patients after Norwood operation for HLHS before the 2nd stage of treatment with a focus on different techniques and equipment and to determine the efficacy of interventional treatment.

Material and methods

Patients

There were 161 percutaneous interventions in 88 patients with HLHS at all stages of palliation performed between 2001 and 2010 in the Catheterization Laboratory of the Department of Cardiology, Polish Mother's Memorial Research Institute. There were 47 interventions in 38 patients after stage first Norwood operation. The main reasons for percutaneous treatment in this group were stenosis of the aortic arch/isthmus (20 patients), stenosis of the right ventricle to pulmonary artery shunt (8), stenosis of the proximal pulmonary arteries (6), and secondary restriction of the interatrial communication (4) (Figure 1).

Procedures

Interventional treatment of the aortic arch/isthmus stenosis was attempted in 20 infants between 2 months and 9 months of age. Maximal gradient across the stenosis ranged between 14 mmHg and 82 mmHg with minimal stenosis diameter between 1.5 mm and 4.5 mm. Venous access was used in 15 infants and arterial access in 5 of them.

The latter was used in case of difficulties with balloon placement and in case of disadvantageous anatomical localization of the primary aorta and a risk of coronary

inflow cessation by a balloon catheter (Figure 2). Arterial access was also used during stent implantation and in one case where an attempt to cross with the balloon catheter through the venous system led to a transient 3rd degree AV block.

Both low pressure TYSHAK balloon catheters (NuMed) and high pressure Advance (Cook) and OPTA (Corids) catheters were used. Catheter diameter was adjusted to the diameter of the descending aorta below the stenosis (balloon diameter ranging from +0 to +2 mm). Procedures were performed without general heparinization, but low-molecular weight heparin was used directly after the procedure (Fragmin 100 IU/kg for 3 days). All patients were on chronic treatment with acetylsalicylic acid (Acesan 3 mg/kg) which was not interrupted for the procedure due to central cyanosis and blood inflow through a Sano shunt.

Lifesaving procedures were performed in 8 infants with stenosis of the right ventricle to pulmonary artery shunt. The age of infants ranged from 1.5 months to 5 months, while arterial blood oxygenation during mechanical ventilation with 100% oxygen was between 28% and 67%. Minimal diameter of the Sano shunt stenosis ranged between 1.5 mm and 3 mm with predominantly proximal, periventricular localization (7/8). Interventional treatment consisted of low and high pressure balloon angioplasty and stent implantation at the site of stenosis.

There were 6 children with proximal stenosis of the left (4) and right (2) pulmonary artery. Low pressure balloon angioplasty with the use of a THYSAK balloon catheter was performed in 4 cases and high pressure balloon angioplasty with means of a coronary balloon catheter (Aqua) was done in 2 cases. Procedures were performed through the venous access after placement of the coronary guidewire in the lobular arteries of the dilated branch. The balloon catheter was introduced directly through the Sano shunt without the use of a long introducing sheath. Diameter of the balloon ranged from 4 mm to 6 mm. Due to the need of intervention through the Sano shunt heparin was administered during the procedure. Standard management after stent implantation was used.

Four infants between 6 months and 12 months of age required interventional treatment due to secondary restriction of the interatrial communication. Left-to-right gradient through the interatrial communication ranged from 8 mmHg to 15 mmHg with mean left atrial pressure of 15 mmHg to 24 mmHg. Restrictive flow was registered despite free interatrial communication during stage first of the Norwood operation. Transfemoral access was used for the procedures. The procedure had to be repeated in one infant. At this stage of treatment patients were not qualified for further bidirectional Glenn treatment due to secondary increase of pulmonary pressure. Static balloon atrioseptostomy was done in 2 infants aged 4 months and 7 months (communication diameter 4 mm and 3.5 mm). The result of the procedure was controlled with trans-

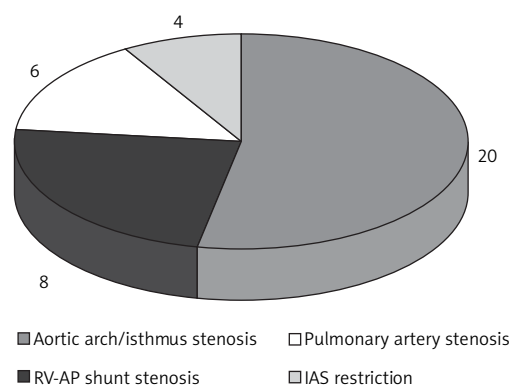


Fig. 1. Patients with HLHS after stage first Norwood operation who underwent interventional treatment. Data distribution according to the indication for intervention

Ryc. 1. Pacjenci z HLHS po pierwszym etapie leczenia sposobem Norwooda poddani zabiegom interwencyjnym. Podział ze względu na wskazanie do interwencji



Fig. 2. Angiographic view of the ascending aorta and coronary arteries. Stenosis located at the site of connection with descending aorta

Ryc. 2. Obraz angiograficzny wstecznie zakontrastowanej aorty wstępującej z odejściem naczyń wieńcowych. Widoczne zwężenie w miejscu połączenia z aortą zstępującą

thoracic echocardiography. Continuous measurement of the blood pressure during retraction of the diagnostic catheter from the left pulmonary veins to the inferior vena cava was performed.

In 2 infants interatrial communication was dilated by stent implantation. Qualification in that case was based

Table 1. Results of percutaneous treatment in patients with HLHS after stage first Norwood operation
Tabela 1. Wyniki leczenia interwencyjnego pacjentów z HLHS po pierwszym etapie terapii sposobem Norwooda

Parameter	Before the intervention	After the intervention	Value of <i>p</i>
CoA diameter [mm]	2.87 ±0.82	5.15 ±0.82	< 0.05
Systolic pressure above CoA [mmHg]	86.52 ±16.44	81.38 ±15.65	< 0.05
Gradient across CoA [mmHg]	29.38 ±15.40	7.14 ±4.28	< 0.05
Diameter of the RV-AP shunt stenosis [mm]	2.28 ±0.48	4.14 ±0.69	< 0.05
Arterial blood oxygenation [%]	52 ±12	75 ±4	< 0.05
Pulmonary artery stenosis diameter [mmHg]	2.33 ±0.51	3.58 ±0.49	< 0.05
Gradient across pulmonary artery stenosis [mmHg]	3.33 ±1.63	2.5 ±1.05	NS
Diameter of the IAS defect [mm]	4.2 ±1.15	9.9 ±3.17	< 0.05
LA pressure [mmHg]	19.4 ±4.1	13.8 ±2.4	< 0.05

CoA – coarctation of aorta, Gr – systolic pressure gradient, RV – right ventricle, AP – pulmonary artery, IAS – interatrial septum, LA – left atrium

CoA – zwężenie łuku lub cieśni aorty, Gr – gradient ciśnienia skurczowego, RV – prawa komora, AP – tętnica płucna, IAS – przegroda międzyprzedsionkowa, LA – lewy przedsionek

mainly on the echocardiographic picture of the stiff septum with more than 2 mm thickness. A Palmaz-Genesis stent was implanted into the interatrial septum in both cases. The procedure was preceded by administration of 100 IU/kg of unfractionated heparin and followed by administration of 100 IU/kg of low molecular weight heparin (Fragmin) for 3 days. Acetylsalicylic acid (Acesan at 3 mg/kg) was given for the whole period beginning with stent implantation. Monitoring of stent position with transoesophageal echocardiography was used.

Statistical analysis

Arithmetic mean, median and standard deviation as a measure of data distribution were used to describe systolic, diastolic and mean blood pressure, stenosis diameter, pressure gradients and increase of arterial blood oxygenation at various stages of treatment. Shapiro-Wilk test was used to test for normality of distribution of the above parameters. Student's *t*-test for independent samples was applied to compare pre- and postprocedural parameters with normal distribution. Variables without normal distribution were compared using a non-parametric Wilcoxon test. All statistical analysis were performed by means of the statistical software STATISTICA, StatSoft, Inc. (2007) v 8.0.

Results

In the group of 20 infants with recoarctation low and high pressure balloon angioplasty procedures led to widening of the stenosis from 2.87 ±0.82 mm to 5.15 ±0.82 mm ($p < 0.05$) and to a decrease of systolic pressure gradient between the aortic arch and descending aorta from 29.38 ±15.40 mmHg to 7.14 ±4.28 mmHg ($p < 0.05$, Table 1). Decrease of systolic pressure above the stenosis was also obtained (86.52 ±16.44 mmHg to 81.38 ±15.65 mmHg, $p = 0.0367$). Rapid recurrence of the stenosis in 1 patient required implantation of the 7 mm × 18 mm Palmaz-Genesis stent (Figures 3 and 4 A-C). The direct postprocedural pressure gradient across the stenosis was lower than or equal to 5 mmHg in 9 infants (45%), ranged between 5 mmHg and 10 mmHg in the next 4 of them (20%), and was higher than or equal to 10 mmHg in 7 infants (35%), which was an indication for repeated balloon angioplasty during catheterization performed after stage 2 of treatment (Figure 5).

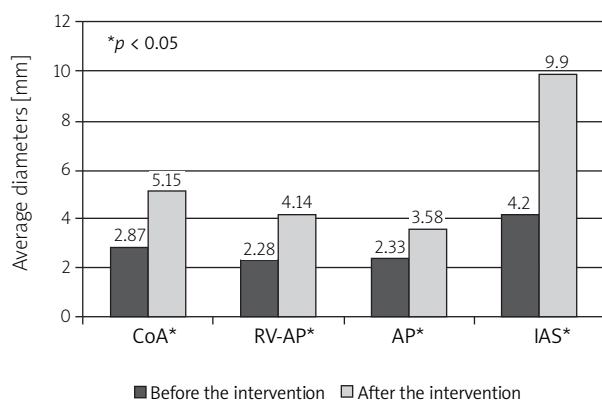


Fig. 3. Average diameters of stenosis of the aortic arch/isthmus, RV-AP graft, pulmonary artery and interatrial septum before and after the intervention
 See Table 1 for abbreviations

Ryc. 3. Średni wymiar zwężenia kolejno łuku lub cieśni aorty, graftu RV-AP, zwężenia tętnicy płucnej, połączenia międzyprzedsionkowego (IAS) przed interwencją i po interwencji
 Skrót jak w tabeli 1.

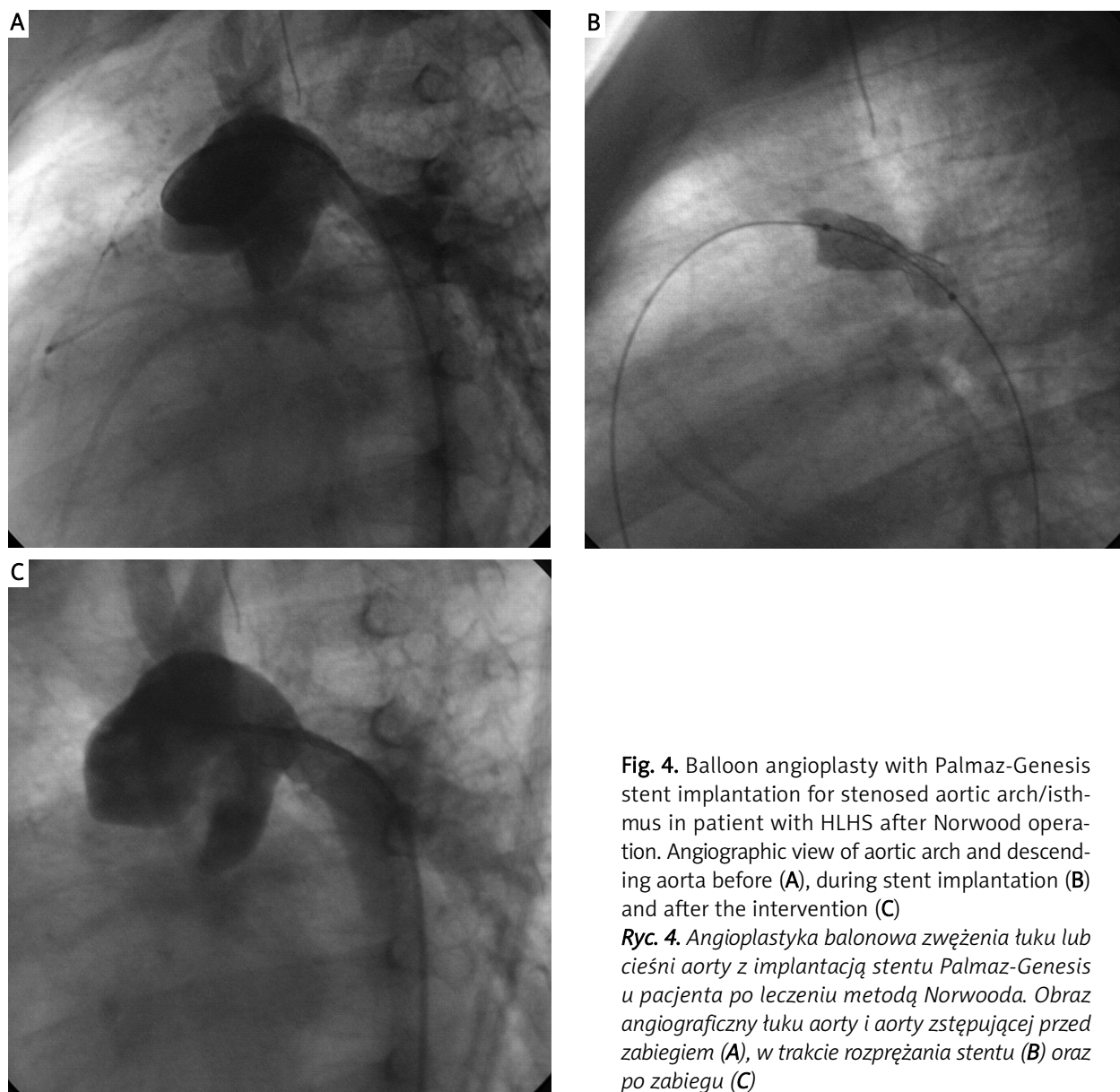


Fig. 4. Balloon angioplasty with Palmaz-Genesis stent implantation for stenosed aortic arch/isthmus in patient with HLHS after Norwood operation. Angiographic view of aortic arch and descending aorta before (A), during stent implantation (B) and after the intervention (C)

Ryc. 4. Angioplastyka balonowa zwężenia łuku lub cieśni aorty z implantacją stentu Palmaz-Genesis u pacjenta po leczeniu metodą Norwooda. Obraz angiograficzny łuku aorty i aorty zstępującej przed zabiegiem (A), w trakcie rozprężania stentu (B) oraz po zabiegu (C)

Critical stenosis of the right ventricle to pulmonary artery shunt was treated successfully in 7 of the 8 infants (87%). Percutaneous balloon angioplasty was sufficient in 5 cases (62%), while in 2 cases (25%) intra-arterial stents were implanted into the Sano shunt. Arterial blood oxygen increased from $52 \pm 12\%$ to $75 \pm 4\%$ ($p = 0.002$) and the diameter of the stenosis increased from 2.28 ± 0.48 mm to 4.14 ± 0.69 mm ($p = 0.0025$).

In 1 case the stent was pulled back from the Sano shunt into the right ventricle during retraction of the balloon catheter. After stabilization of the stent within the right ventricle with the use of a guidewire the child was referred for bidirectional Glenn surgery with removal of the stent from the right ventricle.

Six patients after stage first of the surgical palliation underwent balloon angioplasty of the tight proximal

pulmonary artery stenosis with the balloon catheter introduced through the Sano shunt. The diameter of stenosis increased from 2.33 ± 0.51 mm to 3.58 ± 0.49 mm ($p = 0.0099$); however, decrease of the pressure gradient from 3.33 ± 1.63 mmHg to 2.5 ± 1.05 mmHg was statistically insignificant.

In patients with secondary restriction of the interatrial communication was successfully widened from 4.2 ± 1.15 mm to 9.9 ± 3.17 mm ($p = 0.0079$) and left atrial pressure decreased from 19.4 ± 4.1 mmHg to 13.8 ± 2.4 mmHg ($p = 0.0075$). In half of the patients it was sufficient to perform static atrioseptostomy whereas the second half required stent implantation into the IAS (Figure 7). In 1 case the implanted stent was successfully redilated due to hypertrophy and recurrence of restriction.

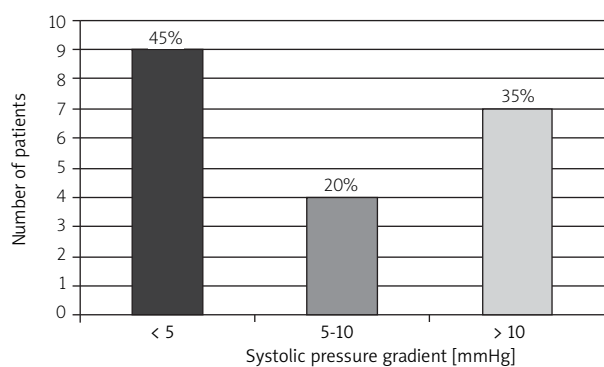


Fig. 5. Systolic pressure gradient after interventional dilatation of stenosed aortic arch/isthmus
Ryc. 5. Gradient ciśnienia skurczowego po interwencyjnym poszerzeniu łuku lub cieśni aorty

Discussion

Therapeutic management of children with HLHS is multistage and carries a significant risk of complications. A special group of problematic patients includes those with suboptimal results of the multistage treatment requiring additional interventional procedures due to various complications [1-4].

The estimated frequency of recoarctation in patients after the Norwood procedure ranges from 9.2% to 20% [5]. In spite of the functionally right ventricular character of the single ventricle heart, it seems reasonable to consider early qualification for intervention when the direct gradient across the aortic arch/isthmus stenosis exceeds 10 mmHg [1, 3, 6].

This situation is justified by different physiology of the systemic right ventricle in which increased pressure overload potentially leads to the onset or progression of

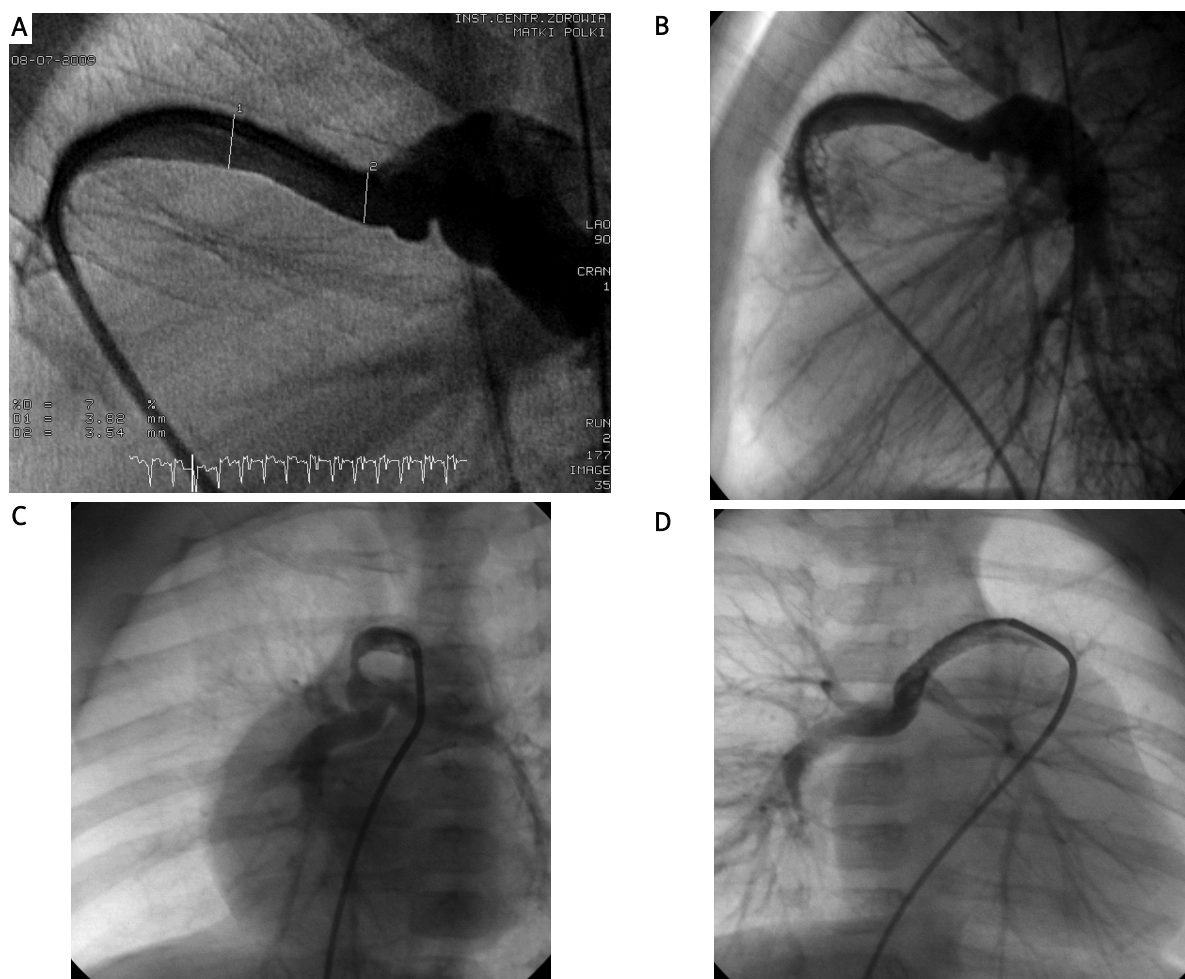


Fig. 6. Angiographic view of the proximal critical stenosis of the RV-AP shunt (A). Palmaz-Genesis stent implanted into the proximal segment of RV-AP shunt (B). Angiographic view of the patient with distal stenosis of the RV-AP shunt before (C) and after Coroflex stent implantation (D)

Ryc. 6. Obraz angiograficzny ciasnego, proksymalnego zwężenia zespolenia komorowo-płucnego (A). Stent Palmaz-Genesis implantowany w zwężenie proksymalne zespolenia komorowo-płucnego (B). Obraz angiograficzny pacjenta ze zwężeniem dystalnym zespolenia komorowo-płucnego (C) z widocznym stentem Coroflex (D)

the tricuspid valve regurgitation. The end-point for intervention was defined as reduction of the direct gradient by at least 70% in comparison to the baseline values or as gradient reduction ≤ 10 mmHg. In most cases of recoarctation, balloon angioplasty was performed with venous access, which certainly decreased the risk of significant, local vascular complications, more frequently present after femoral artery puncture. On the other hand, there was a higher risk of arrhythmia and conduction abnormalities related to introduction of a stiff balloon catheter through the systemic right ventricle.

The success of surgical treatment of patients with HLHS depends mainly (as in most children with a so-called single ventricle heart) on the restoration of optimal morphological and haemodynamic parameters of the pulmonary circulation. The presence of stenoses or segmental hypoplasia of the pulmonary branches increases the risk of additional procedures [7]. The Norwood operation results in the change of geometry of the pulmonary vessels and the frequency of proximal stenosis, especially in patients treated using a Sano modification, is estimated to range between 42% and 58% [8].

Despite higher frequency of proximal stenoses, the Sano modification leads to reduction of mortality after stage first of treatment and better stimulates the development of peripheral pulmonary vessels in comparison to the Blalock-Taussig shunt. If the only pulmonary circulation inflow tract consist of the Sano shunt, isolated balloon angioplasty should be used despite the known lack of permanent effect of treatment. Stent implantation may be attempted intraoperatively simultaneously to treatment with bidirectional Glenn or directly after the surgery [9].

Restrictive interatrial communication in patients with HLHS is a significant determinant of the negative result of surgical treatment [10-12]. The presence of free interatrial flow after the Norwood stage first operation indirectly affects the normal pulmonary pressure values and is one of the elements determining success of the bidirectional Glenn procedure. This problem may have the form of a primary restriction of the interatrial communication leading to increased pulmonary pressure already in the fetal period and causing changes of the small pulmonary arteries which limit the chances for any type of palliative procedure after birth. In a small subset of children a secondary restriction of the communication occurs despite excision of the interatrial septum which is caused by the gradual growth of the interatrial septum. Percutaneous intervention may be an alternative to surgery in both of these situations [11, 12].

In the presented cases, decompression of the left atrium consisted of balloon angioplasty (static atrio septostomy) or intravascular stent implantation into the interatrial septum. The first method is more effective in the case of a thinner interatrial septum but the final result of the procedure, especially the width of the communication, may

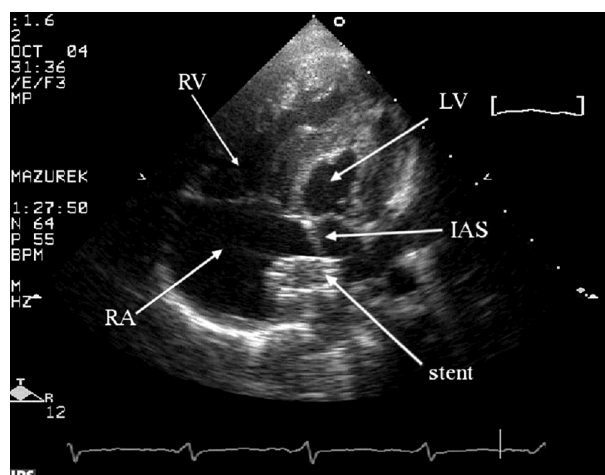


Fig. 7. Transthoracic echocardiography – four-chamber view. Image of the stent implanted into the interatrial septum

RA – right atrium, RV – right ventricle, LV – left ventricle, IAS – interatrial septum

Ryc. 7. Badanie echokardiograficzne przezklatkowe – projekcja czterojamowa. Obraz stentu implantowanego do przegrody międzyprzedsionkowej
RA – prawy przedsionek, RV – prawa komora, LV – lewa komora, IAS – przegroda międzyprzedsionkowa

not be objectively measured [13]. Stent implantation into the interatrial septum is reserved for cases of stiff and thickened interatrial septum and requires the introduction of antithrombotic treatment, which is not necessary after balloon atrioseptostomy [4, 11, 12]. Stents are removed during the next stages of surgical treatment with the use of extracorporeal circulation. Because of the large number of complications, especially deaths in patients undergoing atrioseptostomy using a Park blade, this technique was not used in infants [13].

The Sano modification consisting of the right ventricle to pulmonary artery shunt implantation reduces mortality after stage first of treatment. The occurrence of tight shunt stenosis is a direct threat to life and requires emergency treatment. The clinical condition of an infant is usually very severe, with significant hypoxia and acidosis and therefore interventional procedures allowing widening of the stenosis are useful. Published data demonstrate that interventional treatment is based on stent implantation into the stenosis (most frequently coronary stents). In the presented material the authors performed initial predilation of the stenosis with a balloon catheter while a decision to implant a stent was based on the effect of angioplasty – increase of arterial blood oxygenation and widening of stenosis. Initially stents were implanted without the use of a long introducing sheath [14, 15] and subsequently after placement of the sheath tip inside the right ventricle.

Conclusions

Percutaneous interventions in patients with HLHS after stage first of the Norwood operation lead to haemodynamic stabilization prior to the next step of treatment, increase of oxygen arterial blood saturation and decrease pulmonary arterial pressure, therefore lowering the number of required operations.

Atypical, rescue interventions such as stenting of the interatrial septum or critically stenosed Sano shunt should be considered in deteriorating patients despite the risk of complications if there are measurable potential benefits.

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