

# Percutaneous dilatation of aortic coarctation with balloon angioplasty and/or stent implantation – own experience

Przeznaczyniowe poszerzanie koarktacji aorty za pomocą balonowej angioplastyki i/lub implantacji stentu – doświadczenia własne

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## Abstract

**Background:** Results of percutaneous dilatation of native aorta coarctations (CoA) and recoarctations after previous surgical procedures (ReCoA) are not frequently published.

**Aim:** To assess results of balloon angioplasty (BAP) and/or stent implantation (SI) in the treatment of patients (pts) with aortic coarctation and recoarctation.

**Material and methods:** BAP and/or SI were performed in 203 pts: 110 with native CoA and 93 with ReCoA, aged 0.3-57 (median 15) years. In cases of discrete native CoA BAP was performed with usually low pressure balloons whereas in ReCoA high pressure balloons were used. Depending on the availability the following stents were applied – Palmaz, Cheatham Platinum (CP), covered CP and nitinol self-expandable.

**Results:** BAP was performed during 184 procedures and SI was done in 64 pts. In native aorta coarctation BAP was successful in 82.9% of pts and in all 45 pts with SI (despite 4 stent migrations) a good result was obtained. In ReCoA BAP was effectively performed in 79.2% of pts, whereas SI – in 72.2% (13/18) pts (stiff postsurgical lesions). After BAP/SI aortic aneurysm/dissection occurred in 1 patient with native CoA and in 3 pts with ReCoA – 3 of them were treated with covered stent and one was treated surgically. In a 53 years old woman with native CoA and an aortic aneurysm a mild stroke occurred during an implantation of a covered stent. One 6.5 years old girl suffered from femoral thrombosis after SI and required surgical treatment.

**Conclusions:** In the majority of patients with aortic coarctation BAP or SI are the effective methods of treatment. The treatment strategy should be however always selected individually.

**Key words:** coarctation of aorta, angioplasty, stent implantation

## Streszczenie

**Wstęp:** Wyniki dotyczące przeznaczyniowego poszerzania natywnej koarktacji aorty (CoA) oraz rekoarktacji po jej uprzednim leczeniu chirurgicznym (ReCoA) nie są zbyt często publikowane.

**Cel:** Określenie skuteczności angioplastyki balonowej (BAP) i/lub implantacji stentów (SI) u pacjentów z CoA i ReCoA.

**Materiał i metody:** Angioplastykę balonową i/lub SI wykonano u 203 pacjentów w wieku 0,3–57 lat (mediana 15 lat) – 110 z natywną CoA i 93 z ReCoA. Podczas BAP w przypadkach zlokalizowanej CoA zwykle stosowano balony niskociśnieniowe, a w przypadkach ReCoA wysokociśnieniowe. W zależności od dostępności używano następujących typów stentów: Palmaz, Cheatham Platinum (CP), *covered* CP i nitinolowe samorozprężalne.

**Wyniki:** Angioplastykę balonową przeprowadzono łącznie podczas 187 zabiegów, SI podczas 64. W przypadku CoA BAP była efektywna u 82,9% pacjentów, natomiast SI u wszystkich chorych (pomimo przemieszczenia stentu u 4 osób). W przypadku ReCoA BAP była skuteczna u 79,2%, a SI u 72,2% (13/18) pacjentów (obecność niepodatnych zmian pochirurgicznych). Obecność tętniaka lub rozwarstwienia aorty po BAP stwierdzono u jednego chorego z CoA oraz u 3 z ReCoA. Powikłanie to zostało zaopatrzone poprzez zastosowanie stentu *covered* u 3 pacjentów a u jednego – kardiochirurgicznie. Udar ośrodkowego układu nerwowego wystąpił u 53-letniej kobiety z CoA i samoistnym tętniakiem aorty, u której planowo wszczepiano stent *covered*. U 6,5-letniej dziewczynki po SI wystąpiła zakrzepica tętnicy udowej, która wymagała chirurgicznej trombektomii.

**Wnioski:** Angioplastyka balonowa bądź implantacja stentów stanowi efektywną metodę leczenia CoA lub ReCoA u większości pacjentów. Strategia leczenia w każdym przypadku musi być dobrana indywidualnie.

**Słowa kluczowe:** koarktacja aorty, angioplastyka, stenty

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## Introduction

Coarctation of the aortic isthmus constitutes about 6% of congenital heart defects [1]. In 50% of cases coarctation is associated with bicuspid aortic valve. Coarctation of aorta is more common in females with Turner syndrome. In 1980s balloon angioplasty (BAP) was introduced in the treatment of aortic coarctation. At the beginning the use of BAP in native aortic coarctation (CoA) was controversial due to the fear of such complications as an aortic aneurysm formation [2]. Since 1990s BAP has become an alternative for surgery in untreated native CoA and a first choice treatment in postoperative recoarctation of the aorta (ReCoA) [3-5]. Stent implantation is usually efficient in the treatment of varied anatomic variants of the defect such as tubular coarctations coexisting with hypotrophy of the aortic isthmus or recurrent coarctations after balloon angioplasty [6]. In many centers stent implantation (SI) is an established first choice treatment in coarctation of the native aorta. Patients in whom physical development warrants subsequent stent redilatation to the diameter of the adult aorta should be referred for SI.

Although transluminal dilatation of CoA is currently a widely used treatment method the results of such therapy are not frequently published.

The aim of this report is to establish on the basis of our own experience the efficacy of the transluminal dilatation of CoA by means of BAP and/or SI in patients with native CoA and ReCoA.

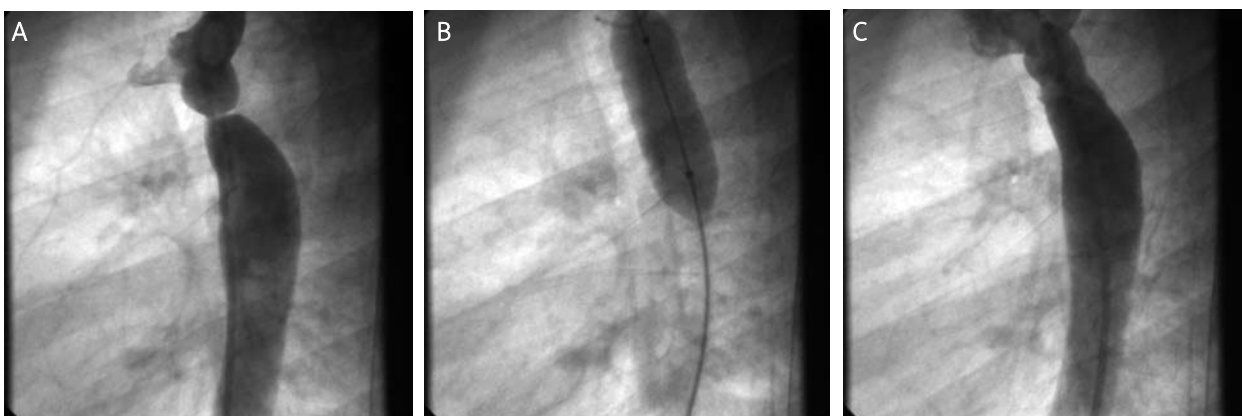
## Material and methods

Between 1994 and 2009 transluminal dilatation of CoA was performed in 203 patients of the age of 0.3-57 years (median 15 years). Children (< 18-year-old) were the majority in the study group (157 children). In all patients the symptoms of systemic upper-body hypertension with a pressure gradient at the aortic isthmus of above 30 mm Hg

by Doppler echocardiography were recognised. Depending on the age of patients, morphology of CoA and previous procedures the BAP and/or SI procedures were performed. The procedure was claimed successful when the pressure gradient in Doppler echocardiography was less than 20 mm Hg in the long term follow up. In cases of localised native CoA low pressure balloons were usually used (TyShak by Numed, fig. 1. A, B, C) whereas in ReCoA high pressure balloons were applied (Maxi by Cordis). Depending on the availability the following stent types were implanted: Palmaz, Cheatham Platinum (CP), covered CP and nitinol self-expandable systems. Palmaz stents are made of steel with sharp ends, CP are round-edged and composed of gold and platinum. Covered CP stents are covered with expandable sleeve. Nitinol systems are made of titanium and nickel.

## Results

Altogether 247 procedures were performed with no fatal complication. BAP was performed as a first choice treatment in 76 patients with native CoA and in 78 patients with ReCoA (tab. 1). Stents were implanted in 63 patients (45 with native CoA and 18 with ReCoA) (tab. 2). In one patient patent ductus arteriosus was closed with intravascular coil simultaneously with the balloon angioplasty procedure, in subsequent 3 patients balloon valvuloplasty of narrowed aortic valve was performed. In 11 patients SI was performed following failed BAP. In other 4 patients with severe CoA SI procedure was performed after scheduled BAP (predilatation). Subsequent redilatation of the stent was performed in 17 patients. In native CoA BAP was unsuccessful in 17.1% of patients (13 patients), whereas all SI procedures were efficient despite stent migration in 4 patients. Stent migration occurred proximally to the stent placement in 2 patients and distally in another two. In all cases however efficient dilatation of coarctation



**Fig. 1. A** – localised membranous type of native aortic coarctation in a 5-year-old boy; **B** – balloon angioplasty (BAP); **C** – good effect of the BAP procedure

**Ryc. 1. A** – miejscowa, błoniasta postać natywnej koarktacji aorty u 5-letniego chłopca; **B** – angioplastyka balonowa (BAP); **C** – dobry efekt zabiegu BAP

**Table 1.** Clinical data and results of balloon angioplasty in the treatment of coarctation of the aorta  
**Tabela 1.** Dane kliniczne oraz wyniki zabiegu angioplastyki balonowej w leczeniu koarktacji aorty

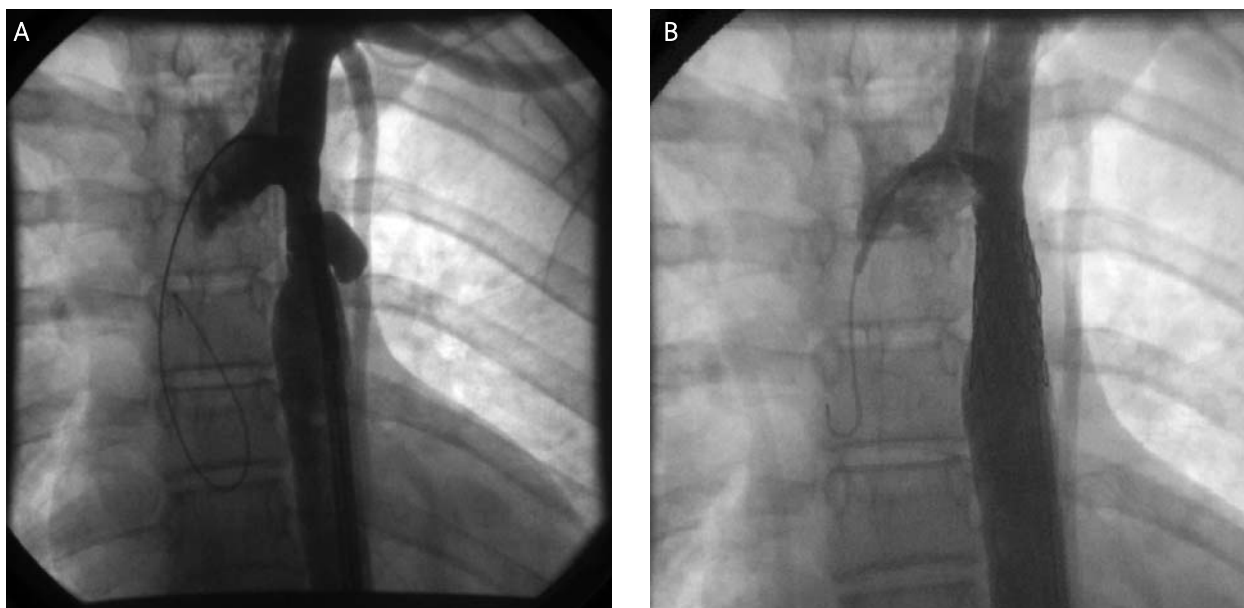
Clinical data	Angioplasty of CoA	Angioplasty of ReCoA
Number of patients	76	78
Age [years] min-max (median)	0.3-46 (10)	0.2-55 (1.3)
Weight [kg] min-max (median)	5.7-85 (29)	2.6-98.5 (10)
Pressure gradient before the procedure [mm Hg] min-max (median)	18-86 (38)	18-90 (34)
Pressure gradient after the procedure [mm Hg] min-max (median)	0-39 (11)	0-44 (12)
Coarctation before the procedure [mm] min-max (median)	1.3-12 (3.6)	1-13 (3.5)
Coarctation after the procedure [mm] min-max (median)	3.2-15 (7)	2.7-16 (6)
Post-procedural to pre-procedural aorta diameter ratio min-max (median)	1 – 4.5 (2)	1-3.2 (1.8)
Balloon to coarctation diameter ratio min-max (median)	1.5-6 (2.7)	1.4-5.5 (2.4)
Reinterventions (number of patients)	22	9
Follow up [years] min-max (median)	0.2-11.5 (4.6)	0.1-15.6 (5.5)
Percentage of failed angioplasty [%]	17.1	20.8

**Table 2.** Clinical data and the results of stent implantation in the treatment of coarctation of the aorta  
**Tabela 2.** Dane kliniczne oraz wyniki zabiegu implantacji stentów w leczeniu koarktacji aorty

Clinical data	Stents in CoA	Stents in ReCoA
Number of patients	45	18
Age [years] min-max (median)	6.5-57 (22)	10-54 (23)
Weight [kg] min-max (median)	25-97 (57)	27-122 (67)
Pressure gradient before the procedure [mm Hg] min-max (median)	18-75 (48)	26-111 (40.5)
Pressure gradient after the procedure [mm Hg] min-max (median)	0-25 (8)	0-37 (14.5)
Coarctation before the procedure [mm] min-max (median)	2-10 (5.0)	3.5-10 (6.3)
Coarctation after the procedure [mm] min-max (median)	5.5-19 (14)	7.5-17 (12.5)
Post-procedural to pre-procedural aorta diameter ratio min-max (median)	1.2-8 (2.4)	1.3-3.8 (1.7)
Balloon to coarctation diameter ratio min-max (median)	1.4-8 (3.2)	1.6-4.6 (2.2)
Reinterventions (number of patients)	8 (successful balloon redilatation)	7 (redilatation in 6, stent implantation in 1)
Follow up [years] min-max (median)	0.1-7.3 (3.2)	0.9-10.5 (4.0)
Percentage of failed procedures	0	failed redilatation in 6 pts

by the migrating stent was observed (Palmaz stents were used in 2 cases – 1 SA, 1 CP). In cases of ReCoA BAP was inefficient in 20,8% of patients (16 patients). Among 18 patients with SI for ReCoA 5 patients had suboptimal stent expansion despite application of a high pressure balloon which was caused by aortic wall changes related to previous surgeries. Three patients with aortic valve incompetence associated with a dilatation of ascending aorta underwent Bentall's procedure: one patient had operation 1 month before SI and 2 other patients were operated on 2 and 5 months after SI procedure. There were 3 cases of aortic aneurysm diagnosed after BAP procedure: in one patient with native CoA and in 2 patients with ReCoA. Two of those patients were treated subsequently with covered stent

implantation and one patient underwent cardiosurgical procedure. A covered stent was used in a 13-year-old girl after two failed balloon angioplasties of CoA to treat an saccular aneurysm at the level of coarctation (fig. 2. A, B). In one case of a 40-year-old male with ReCoA BAP was performed as a predilatation and led to acute dissection of the aorta with a sudden drop in blood pressure. A covered stent was immediately used to close the initial tear of the dissection with successful dilatation of the coarctation. Among other complications a stroke occurred in a 53-year-old woman with native CoA and an aortic aneurysm after a scheduled procedure of covered stent implantation. In a 6.5-year-old girl undergoing SI procedure a femoral artery thrombosis occurred and required surgical thrombectomy.



**Fig. 2. A** – two previous balloon angioplasties in a 13-year-old girl. Tubular type of CoA and saccular aneurysm can be seen. **B** – 34 mm covered CP stent implantation. Separation of the aneurysm from the aortic lumen, dilatation of the hypoplastic aortic isthmus. Stent redilatation planned in future

**Ryc. 2. A** – stan po 2-krotnej balonowej angioplastyce u 13-letniej dziewczynki. Widoczna tubularna postać CoA oraz workowaty tętniak. **B** – implantacja stentu covered CP o długości 34 mm. Oddzielenie tętniaka od światła aorty oraz poszerzenie hipoplastycznego odcinka cieśni. W przyszłości planowana jest redylatacja stentu

## Discussion

Transluminal angioplasty of the coarctation of the aortic isthmus in both native aorta and aortic recoarctation after surgical treatment of the aortic arch has become a first choice treatment over last several years. This does not refer to the youngest patient group up to 6 months of age where cardiosurgery is still the preferable treatment. However, it should be remembered that also in some cases after balloon angioplasty a recurrent coarctation can occur especially in cases of elastic recoil that is a rebound of the fibroelastic tissue in the area of coarctation after balloon dilatation. Balloon angioplasty cannot be performed in aortic hypoplasia when the coarctation is spread along aorta. In those cases stent implantation can be performed.

Stents are made of wire metal mesh. They are fixed on a balloon catheter and subsequently expanded in the region of coarctation to obtain persistent dilatation of the aorta (also in case of longer hypoplastic segments). The limitation of the technique is the need to use large vascular sheaths to introduce stents into the aorta lumen. Therefore they can be used only in patients with body weight of above 25-30 kg thus after 7<sup>th</sup> year of age. On the other hand a future height of the patient and the need for stent redilatation to the diameter of the adult aorta should be taken into account. This treatment method is especially favorable in adult patients with arteriosclerosis and

extensive collateral circulation proximally and distally to coarctation. In this patient group the risk of surgical treatment is exceptionally high (difficult anatomy, presence of collaterals, aortic wall calcifications, risk of paraplegia secondary to spinal cord ischaemia) [7]. The potential risk of stent implantation (similarly to balloon angioplasty of the coarctation) is the aortic wall rupture with aneurysm formation or aortic wall dissection. The procedure involves rupture of the intimal layer and partial rupture of the muscular layer of the aortic wall. The incidence of the aneurysm or dissection is assessed as between 0 to 17% [5, 7-9] but most of the aneurysms are of a small size, do not extend and require only monitoring (follow up imaging, preferably MRI). The incidence between 0 and 9% of large aneurysms (requiring intervention treatment) is reported in literature. In these cases an implantation of a covered stent, which is a stent covered with expandable sleeve (pTFE – polytetrafluoroethylene), is the treatment of choice [10]. It is worth mentioning that according to our own experience a formation of a large aortic aneurysm responsible for the aorto-bronchial fistula can also take place after surgical treatment of CoA [11]. Our own experience also indicates that there is a possibility of non-surgical reconstruction of functionally interrupted aortic arch at the point of CoA by means of a stent implantation [12]. There are hopes for future use of stents that could be implanted in the youngest patient group such as

bioabsorbable stents or stents consisting of two stent halves made of metal and connected by reabsorbable sutures [13]. There is no definite answer which of the interventional methods currently used: balloon angioplasty or stent implantation is better in the treatment of the aortic coarctation [6, 14-19].

It should be emphasised that transcatheter procedures of CoA dilatation should be performed only by the most experienced teams of interventional cardiologists. Additionally it is necessary to provide cathlabs with covered stents (to be used immediately in case of rupture or dissection of the aortic wall during procedure) and cardiosurgical backup. Covered stents were efficient in the treatment of complications in 3 of our patients including two aortic aneurysms post-BAP. An application of a covered stent saved life of a patient with aortic dissection post-BAP.

## Conclusions

Balloon angioplasty or stent implantation are efficient methods of treating CoA in native aorta or recoarctation after cardiosurgical treatment. Treatment strategy should be chosen individually in every case.

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