

# Less invasive percutaneous closure of persistent arterial duct in children below 10 kilos

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## Abstract

**Introduction:** There is quite high risk of vascular complications connected with arterial puncture – mainly in the group of the smallest patients weighing less than 10 kg.

**Aim:** To evaluate a new method of percutaneous closure of persistent arterial duct (PDA) in small children.

**Material and methods:** Six patients were enrolled in this method of PDA closure at the age of 10.67 ±1.97 months. The mean weight was 8.85 ±0.66 kg. The occluders were implanted using only venous access. The position of the occluder was determined by angiography in the pulmonary artery through the delivery system and by echocardiography.

**Results:** The procedure was effective in all six cases but we managed to proceed in the planned transvenous method in five cases. There was one case of complete duct constriction after introduction of the catheter, so precise measurements were impossible. After removal of the catheter the constriction remitted completely. The duct was closed in the standard manner. During echocardiographic examination we found complete closure of all six arterial ducts directly after the procedures and in the follow-up (9.17 ±3.02 months). No stenosis within the pulmonary arteries or aorta were found.

**Conclusions:** Transcatheter arterial duct occlusion without arterial puncture is an effective and safe method of treatment allowing one to reduce the complications connected with arterial puncture. A possible complication of this method may be a constriction of the duct walls as a result of a larger amount of manipulations.

**Key words:** transcatheter intervention, ductus occlusion.

## Introduction

Persistent arterial duct (PDA) may be the cause of some adverse haemodynamic effects. They imply clinical consequences although it is rarely necessary to close it in a very early stage of life. The only group of patients in which closure of a PDA may be necessary is premature babies with circulatory failure and artificial ventilation dependence. In that case the surgical method of patent arterial duct closure was until recently the only accepted method of therapeutic treatment.

The first announcement about transcatheter PDA closure in these patients appeared in 2011. It concerned a 2.2 kg preterm baby who was treated with an Amplatzer Vascular Plug IV [1].

Patients who have managed to change from mechanical ventilation to spontaneous breathing and in whom there was no contraction of the ductus require early but “planned” closure of the PDA. However, this applies only

to patients with haemodynamic consequences, such as enlarged left heart chambers, physical retardation, or frequent infections of the respiratory system.

The arterial duct may be closed with a surgical, thoracoscopic or transcatheter approach [2]. The less invasive method is the interventional method. However, there is quite high risk of vascular complications connected with arterial damage – mainly in the group of the smallest patients in the age below the first year of life. The arterial approach is demanded in all the protocols of transcatheter PDA treatment.

## Aim

For these reasons we started to close persistent arterial ducts using venous access only.

## Material and methods

In the period between 2003 and 2012 there were 125 patients with persistent arterial duct who were treated in our

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centre. The mean age of the patients was 3.8 years (range: 0.55-16.9 years). To occlude the ducts we used vascular coils and Amplatzer Duct Occluders (ADO). The procedures were performed according to the standard protocols, which means that when the coils were used to close the duct we punctured the femoral artery and when the ADO were applied both arterial and venous access was necessary. Due to the fact that in three infants vascular complications requiring long-term administration of heparin occurred, since 2011 we have started to perform these procedures in this group of babies with venous access only.

Six patients were enrolled in such a modified method of PDA transcatheter closure in the age of  $10.67 \pm 1.97$  months (range: 8-14 months). The mean weight was  $8.85 \pm 0.66$  kg (range: 7.9-9.8 kg). In all cases the ducts were haemodynamically significant. The data of the patients are shown in Table 1.

All the procedures were performed in the patients under general anaesthesia with tracheal intubation and with antibiotic coverage. The right femoral vein was punctured and the 4 F sheath was introduced. The multipurpose 4 F catheter was introduced through the inferior caval vein,

right atrium, right ventricle and main pulmonary artery. The pressures were measured. Using the hydrophilic guidewire the arterial duct was crossed and through the duct a multipurpose catheter was introduced to the aorta. Then the catheter was replaced on the guidewire 0.035 cm  $\times$  260 cm by the 4 F pigtail catheter in such a way that the loop of the pigtail catheter was left in the aorta (most often in the aortic arch) (Figure 1). Aortography was done and based on it the anatomy and the measurement of PDA diameter were estimated. Then the proper size of the ADO was chosen. Its diameter was about 1-1.5 mm larger than the diameter of the narrowest point of the duct. The ADO was implanted with the standard method but the only difference was that the control aortography was not performed. The position of the occluder was determined by the angiography which was performed in the pulmonary artery through the delivery system and by the echocardiography just before (Figure 2) and after the deployment of the duct occluder.

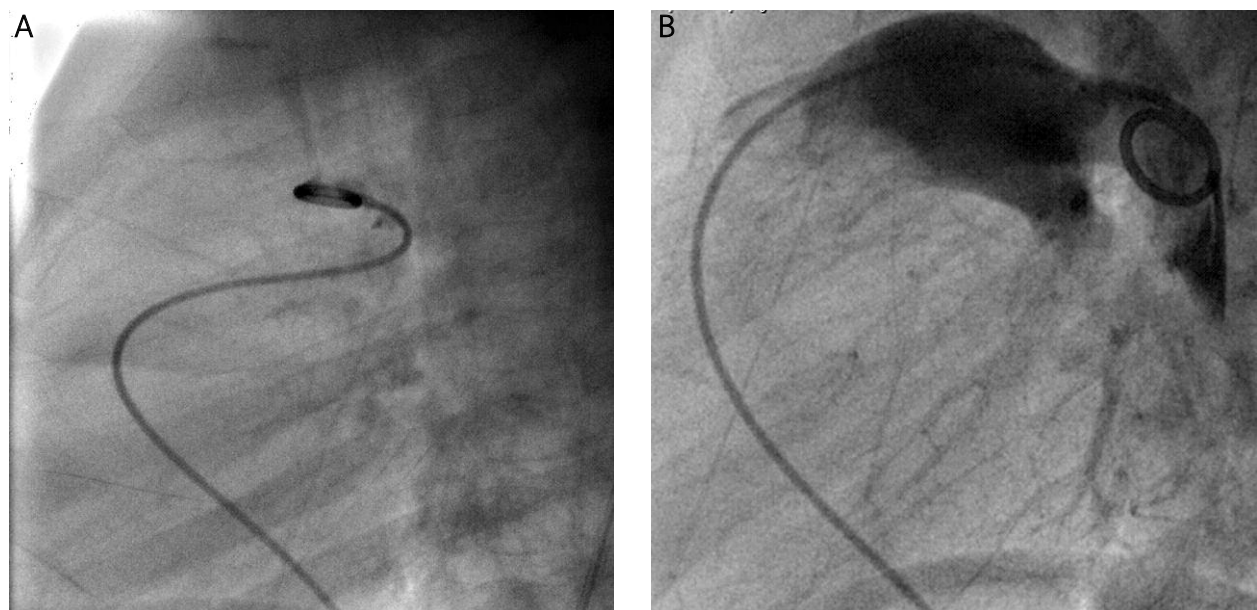
## Results

The procedure was effective in all 6 cases but we managed to proceed in the planned transvenous method in

**Table 1** Data of patients

Patient no.	Age [months]	Weight [kg]	ECHO Qp:Qs	ECHO PDA diameter [mm]	Angio. PDA diameter [mm]	mPAP [mm Hg]
1	11	8.2	3.1	3.6	2.8	22
2	14	9.3	2.9	4.1	2.9	24
3	10	9.2	2.6	3.3	2.6	24
4	8	7.9	2.8	3.5	3.2	28
5	9	8.7	2.2	3.5	2.7	19
6	12	9.8	2.4	3.6	3.0	25

Qp:Qs – pulmonary-systemic flow ratio, PDA – patent ductus arteriosus, mPAP – mean pulmonary arterial pressure



**Fig. 1. A** – The pigtail catheter is introduced through the pulmonary artery, persistent arterial duct and the loop of the catheter is placed in the aortic arch. **B** – Angiography performed with the catheter placed inside the duct



**Fig. 2.** Echocardiography just before the detachment of the Amplatzer Duct Occluder

5 cases. In one patient, although we started the procedure with only venous puncture, the whole intervention had to be done in a standard manner. During the introduction of the pigtail catheter through the arterial duct reactive constriction of PDA occurred and after the aortography we observed no shunt through the duct (Figure 3 A). In such a situation we had no solution other than to remove the catheter, leaving the guidewire in the duct. In the meantime the right femoral artery was punctured and after introduction of the 4 F sheath the diagnostic pigtail catheter was inserted into the aorta. After the second aortography we also could not observe the shunt through the duct (Figure 3 B). So we had to remove also the guidewire from the duct and after that the constriction of PDA completely remitted after 10 min (Figure 3 C). The duct was closed in the standard manner with no other complications.

After control echocardiographic examination we found complete closure of all six arterial ducts directly after the procedures and in the follow-up (mean 13.6 ±5.02 months). No stenosis within the pulmonary arteries or aorta were found.

## Discussion

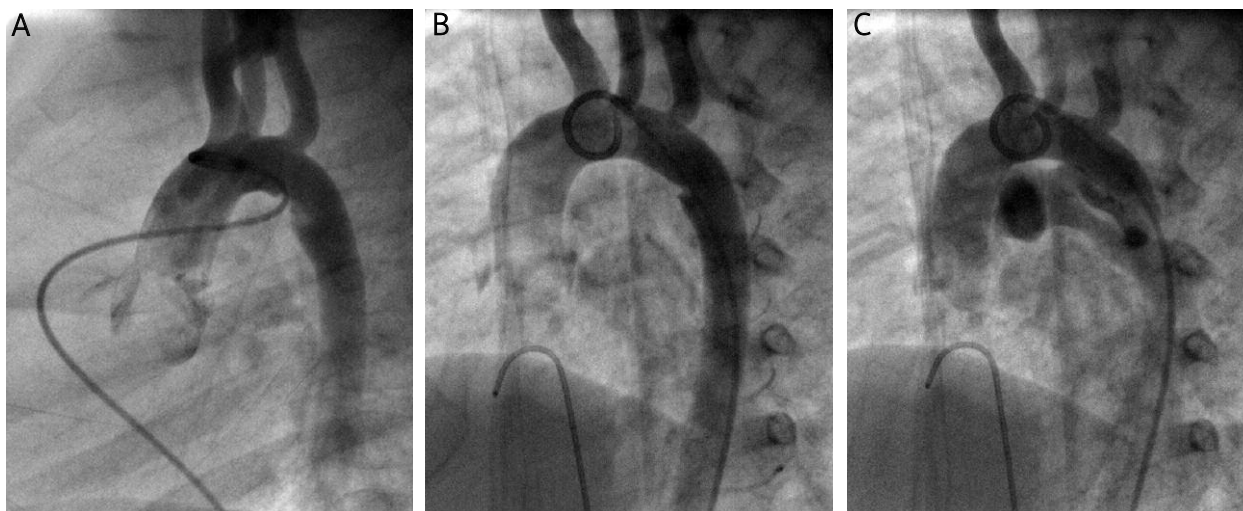
Percutaneous closure of the ductus arteriosus is the method of choice for treatment of this malformation in all age groups, except for the youngest patients, i.e. those whose weight is less than 5-6 kg. For them, the surgical treatment is recommended, although there are already reports of percutaneous closure of the ductus arteriosus in a premature baby of 2.2 kg body weight.

The surgical approach is still a standard method of treatment for them although there are reports of transcatheter arterial duct closure in premature babies of 1.7 kg and 2.2 kg body weight [1, 3].

The limitations in this age group are connected with the lack of suitable delivery systems small enough to be safe for such tiny vessels. It is also a rule that arterial ducts in this period of life are often much wider than in older groups, so they require the introduction of larger implants. In the presence of small diameter of the blood vessels it can lead to their narrowing or even occlusion.

The next problems that may occur are vascular complications connected with the arterial puncture. It concerns patients with low body weight. In most of the cases it is possible to postpone the date of intervention until it is safe for the patient and allows one to avoid complications but in some cases the closure of the duct should not be postponed too long because of the danger of development of pulmonary hypertension or heart failure.

According to the data from the literature, vascular complications occur most frequently in patients with body



**Fig. 3. A** – Angiography revealed complete constriction of the duct. **B** – Aortography immediately after removing the catheter from the duct. **C** – Aortography performed 10 min after removing the catheter

weight below 10 kg. More than 20 years ago about 60% of patients had the pulse over the punctured artery impalpable or very weak at the time of discharge [4]. Low profile vascular sheaths, minimized delivery systems and implants reduced the percentage of vascular complications although it is still high in the youngest group of patients.

The latest data show that arterial occlusion concerns about 16% of the patients with body weight lower than 10 kg and 5.5% of patients with higher body weight [5]. Avoiding the arterial access eliminates all possible complications connected with arterial puncture: its occlusion, embolism, dissection, pseudoaneurysm formation, and bleeding.

Certainly it does not exclude venous complications, which are as probable as arterial ones, but their consequences are definitely less important. The most serious arterial complications may end up with leg amputation or unequal development of lower extremities.

The new method of PDA occlusion seems to be an attractive therapeutic proposal. The biggest difficulty in this method is the lack of precise angiographic imaging immediately before deployment of the device. Based on our experience, good echocardiographic visualization is sufficient for the safety of the procedure. The experienced echocardiographer is able to determine precisely the location of the occluder. During the echo imaging we are able to estimate the flow in the aorta and in both pulmonary arteries in order to be sure that none of the vessels (especially the left pulmonary artery) are narrowed [6]. An additional advantage of our method is the reduction of the volume of contrast medium.

Sometimes there are problems in passing the guidewire through the arterial duct from the pulmonary artery. In such situations it is not possible to perform the PDA closure only from the venous approach. It is far easier to go through the duct from the aortic side and in those patients it is unavoidable to puncture the femoral artery. Then after passing the guidewire from the aorta through the duct to the pulmonary artery we exteriorize it using a vascular goose neck wire. After that it is possible to introduce the delivery system with the occluder.

An additional complication that appeared in one of our patients was the vasoconstriction of the duct. The structure of this vessel may predispose to constriction as the reaction to different factors [7]. We dealt with such a situation in our patient. The modified method of duct occlusion that we propose comprises additional manipulations within the duct and that was probably the reason for the temporary total constriction of a large arterial duct in 1 of our patients. Ten minutes after the removal of all devices from the lumen of the duct we saw the relaxation of the duct walls and then we were able to occlude the PDA effectively. Such reaction of the duct walls is more likely to happen in younger patients when fibrosis or calcification has not been developed. It is quite important to be aware of

the possibility of such a complication and it should always be considered when the differences between the diameter of the duct before and during the procedure become substantial. It may end up with the choice of too small an occluder and, in consequence, the migration of the device.

## Conclusions

Transcatheter arterial duct occlusion without arterial puncture is an effective and safe method of treatment allowing one to reduce the complications connected with arterial puncture. A possible complication of this method may be a constriction of the duct walls as a result of a large amount of manipulations inside the duct.

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