ORIGINAL ARTICLE

Percutaneous transcatheter closure of patent ductus arteriosus: Initial experience of Sohag University

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Patent ductus arteriosus; Amplatzer duct occluder; Nit occlude PFM coil; Detachable Cook coil

Abstract Objectives: Initial experience with transcatheter closure of patent ductus arteriosus (PDA) using different types of devices is reported in Sohag University Hospital. We evaluated the outcome, complications, and also assessed the need of surgical backup for such interventional procedures.
Methods: From March 2011 to September 2012, 51 patients who underwent transcatheter closure of PDA, were retrospectively identified and studied. Aortic angiogram was performed to evaluate the size, position, and shape of the duct for appropriately choosing the occluder device type and size. A second aortic angiogram was performed 10 min after device deployment. Echocardiography was repeated at intervals of 24 h, then at 1, 3, and 6 months after the procedure to assess complications. The PDA was closed by Amplatzer Duct Occluder (ADO) in 40 patients, Nit occlude PFM coil in five patients, Amplatzer muscular VSD in two patients and Detachable Cook coil in four patients.
Results: Of 51 cases, one patient had left pulmonary artery embolization of ADO that required surgical intervention. The PDA was successfully closed in 98.04% of the study population without any residual PDA shunting. All the patients were alive. Infants made up 29% of the total patients. 45 patients were children and six patients were adults.
Conclusion: Our initial results show that transcatheter occlusion of PDA using different types of devices is safe and effective with good midterm outcome alternative to surgery. Complications occurred in those with unfavorable duct anatomy and presence of pulmonary hypertension. Surgical backup was not important for such interventional procedures.

1. Introduction

Patent Ductus Arteriosus (PDA) is a common form of congenital heart disease. It has been estimated to occur in 1 in 2500–5000 live births. As an isolated lesion, it represents 9–12% of all congenital heart diseases.¹ The presence of volume overload of the left atrium and left ventricle is an indication for closure of the defect. Closure eliminates left to right shunt, volume...
overload of the left-sided circulation, the risk of pulmonary hypertension and the risk of infective endocarditis.

Gross et al.\textsuperscript{2} began the era of Congenital Heart Surgery when they reported the first successful ligation of a Patent Ductus Arteriosus (PDA). Porstman et al.\textsuperscript{3} were the first to use a new method by which a PDA was closed successfully by Ivalon foam plug via combined femoral artery and vein approach. The Rashkind device\textsuperscript{4} the buttoned device,\textsuperscript{5} the Botolloccluder device\textsuperscript{6} and coils\textsuperscript{7} have been used extensively for transcatheter closure of PDA with variable degrees of success. Masura et al.\textsuperscript{8} had reported the use of the new Amplatzer Duct Occluder (ADO) in humans to close the PDA by the transcatheter approach.

Transcatheter closure of small to moderate PDA is now an established method of treatment for most patients with PDA.\textsuperscript{9} We would like to share our experience of transcatheter closure of PDA in Sohag University Hospital.

2. Materials and methods

All patients who had undergone transcatheter closure of PDA between March 2011 and May 2012 in Sohag University Hospital were included in this retrospective study. The patients who were selected for this device occlusion were those with clinical and echocardiographic features of PDA and weighed \( \geq 5 \) kg. These patients had one or more of the following: symptoms and signs of cardiac failure requiring medications, failure to thrive, bounding pulses, cardiomegaly on chest radiography and at least moderate dilation of the left atrium and ventricle on two-dimensional (2D) echocardiography. One patient had a small ventricular septal defect (VSD); two patients had previous surgical correction for PDA but canalization had occurred, one patient had bicuspid aortic valve with mild aortic stenosis and moderate aortic regurgitation and two patients had small subaortic membrane with mild LVOT obstruction. There were a small number of adolescents and adults who had exercise intolerance (NYHA class II) and PDA measuring \( \geq 5.0 \) mm at the narrowest end on 2D echocardiography and were included for this method of occlusion.

The patients’ clinical characteristics e.g. age, sex and weight were recorded. Informed consents were obtained from all patients. Aortic angiogram in lateral and right anterior oblique views was performed to evaluate the size, position, and shape of the duct for appropriately choosing the occluder device type and size. The hemodynamic data including pulmonary artery pressure and the Qp/Qs. The technique of device deployment was similar to that reported in the literature.\textsuperscript{27,28} Detachable or PFM coils were used for patients with small PDAs of \( \leq 2.5 \) mm at the narrowest diameter (Fig. 1). ADOs were used for PDAs that were \( > 2.5 \) mm. ADO size selected was usually 1–2 mm larger than the duct diameter in children. (Fig. 2)\textsuperscript{10} However, some exceptions to this rule had to be made due to unavailability of the devices at the time of procedure. The two Amplatzer muscular VSD devices were used in type E PDAs which had long length. A second aortic angiogram was performed 10 min after device deployment (Figs. 3 and 4). The fluoroscopy time during the procedure was identified. The transcatheter occlusion was performed under general anesthesia in all infants and small children or under sedation and local anesthesia in the older patients.
The complications that arose from the procedure were also recorded. Patients had follow-up in Pediatric Cardiology Out-patient Clinic at intervals of 24 h then 1, 3, and 6 months after the procedure. Patients were checked clinically for any evidence of cardiac murmur during each follow-up. Complete echocardiographic data (left pulmonary artery and aortic Doppler interrogation) in addition to the evaluation of residual shunting was obtained by using echocardiography machine General Electric vivid S5.

Univariate analyses were performed by using SPSS Statistics 17.0. Different devices were used, the most common were Amplatzer duct occluder 1 and Nit occlude PFM coil. The patients’ clinical characteristic and outcome were expressed as mean ± standard deviation and median.

### 3. Results

A total of 51 patients underwent transcatheter closure of PDA between March 2011 and September 2012. It comprised of 38 females and 13 males. The clinical profiles of all the patients were shown in Table 1. There were a total of fifteen patients under 1 year old. There were six adult patients.

The clinical and hemodynamic data and results of PDA closure are shown in Tables 1 and 2. The mean pulmonary end of PDAs was 3.6 mm (range 1.3–8 mm) by angiography. The mean pulmonary to systematic flow ratio Qp/Qs was 1.7:1 (range 1.2:1–3:1). The procedure was successful in all the PDAs except one patient.

Six patients had trace angiographic residual shunt with foaming through the device with contrast jet.

The mean fluoroscopy time was 15 min (range 5–20 min) and the mean total procedure time was 33.6 min (range 20–40 min).

This study included 15 infants, the clinical and hemodynamic data are shown in Table 3. The mean age was 8.2 months and the mean weight was 7.6 mm kg. The mean PDA diameter at the narrowest point was 2.3 mm.

Complication occurred in one infant in the form of ADO embolization. One infant had large tubular PDA (type E) which was closed by Amplatzer muscular VSD 6 mm. Another infant had large tubular PDA without pulmonary construction and the procedure was aborted as PDA closure required ADO II which was unavailable in Egypt. ADO was used in thirteen infants and PFM coil was used in two infants.

Using the classification adopted by Krichenko et al.11,12 42 patients had type A (well-defined ampulla at the aortic end and constriction at the pulmonary artery end), two patients had type E (long with remote constriction) and one infant had type C PDA.

In our experience, ADO was the most common device used in this study (87%). Our protocol in this study to use the ADO in moderate and large PDA in children and in adult patients, is in contrast to the Nit-Occlud PFM and Detachable Cook coils used in small PDA. Amplatzer muscular VSD occluder was used in two children who had PDA type E as shown in Figs. 5 and 6.

There was no evidence of obstruction of the left pulmonary artery or the descending aorta, as confirmed by 2D-Doppler in the following day follow-up.

No patient required blood transfusion. There were two infants who had temporary loss of femoral arterial for two days, they received low molecular weight heparine. All the other patients were discharged home one day after the closure and no patient had residual shunt on Color Doppler Echocardiography after 24 h.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD or %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>8.19 ± 1.79</td>
</tr>
<tr>
<td>Sex(M/F)</td>
<td>3/12 (20%/80%)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>7.56 ± 1.95</td>
</tr>
<tr>
<td>Pulmonary end of PDA(mm)</td>
<td>2.29 ± 0.79</td>
</tr>
<tr>
<td>Aortic ampula of PDA(mm)</td>
<td>8.2 ± 2.52</td>
</tr>
<tr>
<td>Qp/QS</td>
<td>1.9/1 ± 1.2/1</td>
</tr>
</tbody>
</table>

The clinical profile and hemodynamic data of infant group of patients.

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![Figure 4](image-url) Descending aortogram showing the Nit occlud PFM in the PDA position without shunt before its release.
4. Complication

There was one patient (3.3%) who experienced complication during the procedure with Amplatzer duct occluder embolization to the left pulmonary artery. The patient’s weight was 6 kg with the age of 9 months and the PDA was closed with ADO size 8/6 mm without residual shunt in second aortogram. During release of device, embolization occurred spontaneously. We thought embolization occurred secondary to increased flow through the patent ductus arteriosus with possible under-sizing of the device. The patient was referred to surgery for device removal and closure of PDA. No catheter retrieval was attempted.

Twenty-one out of forty-four patients had completed 6-months and 12-month follow-up and all patients were found to have complete closure with no evidence of device migration, recanalization, thromboembolic episodes, wire fracture, hemolysis or endocarditis.

5. Discussion

PDA occurs in 9–12% of all congenital heart defects. Once the diagnosis of the uncomplicated PDA is established, closure is recommended by surgery or catheter occlusion to avoid pulmonary overflow and prevent infective endocarditis. Transcatheter closure of PDA has been the mainstay of treatment in children and adults. Overall PDA closure rate was 94% and major adverse events were 1.5%. There have been only a few minor complications in our study compared with the initial interventional data. Nevertheless, procedure-associated complications have been still described in different age groups, and they are relatively major in infants. Information is also inadequate regarding safety and feasibility of transcatheter closure in infants. Few studies have investigated their usefulness in children weighing less than 10 kg.

That meets our results which included 13 infants. The PDA was closed successfully in 11 infants. Major complication in the form of embolization of ADO occurred in one infant and the procedure was aborted in another infant who had large tubular PDA (type C).

In the present series, transcatheter closure was performed in 51 patients with the PDA diameter at pulmonary end ranging from 1.3 mm to 8 mm. The youngest age group was 6 months old with 5 kg in weight. There were six adult patients.

The closure rate in our study population was 98.04%, in which one patient (3.3%) had complication of ADO embolization and the child was referred to cardiac surgery and the procedure was aborted in one infant due to unavailability of ADO type II. ADO embolization is a well known complication especially in early experience of any cardiac center. This complication has been described in many series.

Coil is still the preferred device in a small PDA (less than 2.5 mm). In our study, two types of coils were used: Nit occlude PFM coil in five patients and Detachable Cook coil in four patients. The ADO was used in moderate and large PDA. However in our study, there is no protrusion of the occlusion device into the aorta or obstruction to the LPA which are common complications of transcatheter closure of PDA.

The results documented in our series are in accordance with the results reported in many other interventional pediatric cardiac centers around the world.

There are many advantages of PDA device closure compared to surgical ligation which include, less invasive, without surgical scar, short hospital course, low morbidity and comparable success rate. However, the surgical ligation is still necessary for large PDA especially in small infants.

6. Conclusion

Our experience with transcatheter closure of PDA is effective and safe with good mid-term outcome, as reported by various interventional pediatric cardiology centers around the world.

Conflict of interest

None.
References