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ORIGINAL ARTICLE

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Transcatheter closure of calcified patent ductus arteriosus in older adult patients: Immediate and 12-month follow-up results

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Abstract

Objective: To present our experience in transcatheter closure of calcified patent ductus arteriosus (PDA) in older adult patients, which has rarely been reported.

Patients: From 2009 to 2014, a total of 16 patients (median age 58 years) with calcified PDA underwent transcatheter closure in our center. All patients were symptomatic with major symptoms being exertional dyspnea (in 12), palpitations (in 8), and fatigue (in 5). A continuous murmur was heard in all patients. The median ductus diameter was 4 mm (range 3–7 mm). The median Qp/Qs was 1.6 (range 1.4–2.9).

Interventions: Transcatheter closure was performed for all patients. The size of the occluder selected was 2–3 mm greater than the narrowest portion of PDA. We experienced difficulties in advancing the multipurpose catheter through the calcified duct in about one third of patients (5/16). Considering that calcified tissue has a greater tendency to rupture, hence, to close PDA in these patients, they adopted the retrograde wire-assisted technique and modified the procedure to reduce the shear stress of sheath and avoid any sheath kinking. For the remaining 11 patients, the advancement of the multipurpose catheter through the calcified duct was smooth and the conventional antegrade approach was applied.

Outcome Measures: Clinical examination, standard 12-lead electrocardiography, chest x-ray, and transthoracic echocardiography were performed before hospital discharge, at 1-, 3-, 6-, and 12-months follow-ups.

Results: All PDAs were successfully closed. There were no deaths. Three patients had a trivial residual shunt, with one also having intravascular hemolysis. Following pharmacological treatment, hemolysis signs vanished at 7 days postprocedure. The trivial residual shunt disappeared in all three patients at 3-month follow-up. No new-onset residual shunt, device embolization, device dislocation, infective endocarditis, or embolism was observed at all follow-up time points.

Conclusion: Successful closure of calcified PDA with few complications in older adult patients was achieved using the duct occluder.

KEYWORDS
calcified patent ductus arteriosus, duct occluder, transcatheter closure

1 | INTRODUCTION

With the development of new devices such as embolization coils and the Amplatzer Duct Occluder (ADO), transcatheter closure has become the preferred technique to manage patent ductus arteriosus (PDA) with high occlusion rates and few serious complications.[1] In contemporary practice coil occlusion is preferred for the closure of small PDAs,[1–4] while the ADO is commonly used for closure of PDAs greater than 2 mm with a sufficient aortic ampulla.[1,5] Calcified PDAs can be seen in adults and it has been generally accepted that closure of a calcified

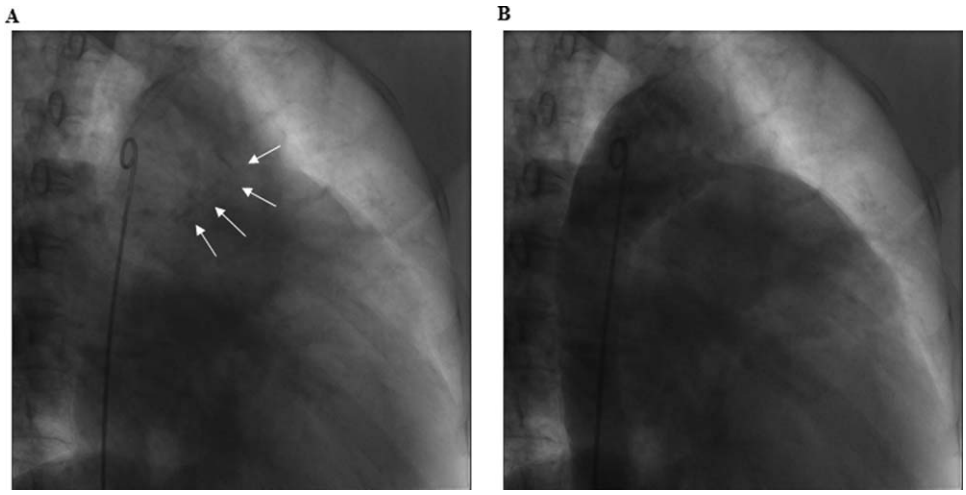

FIGURE 1 Assessment of calcified PDA. A. Representative right anterior oblique view (45°) demonstrating the calcified rim of PDA ampulla (indicated by the arrow). B. Representative proximal descending aorta angiography showing the size and length of a PDA

ductus can be accomplished surgically,[6,7] and with heavy calcification, division and ligation of the ductus with cardiopulmonary bypass support may be necessary.[7,8] There have been reports of transcatheter closure of calcified PDAs using the Rashkind double umbrella device,[9,10] which however often results in significant residual shunts, requiring a second intervention. Here we report the successful transcatheter closure of calcified PDAs using the duct occluder in 16 older patients.

2 | METHODS

2.1 | Patients

From May 2009 to August 2014, 16 patients (2 males, 14 females) with calcified PDAs (sizes ranging from 3 to 7 mm) underwent transcatheter closure at our center. All patients were symptomatic with major symptoms being exertional dyspnea (12), palpitations (8), and fatigue (5). Pulmonary embolism, chronic thromboembolic disease, mitral valve disease, and autoimmune disease as a cause for symptoms were ruled out prior to patient inclusion. A continuous murmur was heard in all patients. Written informed consent was obtained from all patients prior to the procedure. The collection and use of clinical data were approved by the local research ethics board.

2.2 | Transcatheter procedure

The closure procedure was performed with local anesthesia and transthoracic echocardiographic (TTE) and fluoroscopic guidance. The femoral vein and artery were accessed percutaneously. Right heart catheterization was performed to obtain hemodynamic data that were used for calculation of pulmonary vascular resistance. Proximal descending contrast aortography was performed in the lateral and/or right anterior oblique projections to profile the calcified PDA (Figure 1A, B). A PDA occluder sized to be approximately 2–3 mm greater than the narrowest portion of calcified PDA was selected. If a multipurpose catheter could be advanced smoothly through the calcified PDA, a conventional antegrade approach was employed as described previously.[3] Briefly, the catheter was directed into the descending aorta, the device was then deployed under fluoroscopic control, released once the final position was confirmed using angiography and echocardiography. In situations where there was difficulty directing the multipurpose catheter through the calcified PDA in antegrade approach, the retrograde wire-assisted technique was used to establish an arteriovenous wire loop as described previously.[11,12] Briefly, a guide wire was advanced through the right femoral artery, across the PDA to the pulmonary artery where it was snared and exteriorized from the right femoral vein (Figure 2A). The technique was then modified as follows; instead of advancing the delivery sheath into the descending aorta, once the distal tip of delivery sheath passed over the PDA, it was directed into the aorta about 2–3 cm opposite to the ampulla, and the tip directed toward, but not touching the aortic wall (Figure 2B). The device was then deployed and released as described for the antegrade approach (Figure 3A–C).

2.3 | Follow-up protocol

All patients underwent clinical examination and electrocardiographic monitoring for 24 hours postprocedure. Clinical examination, standard 12-lead electrocardiography (ECG), chest x-ray, and TTE were performed before hospital discharge, and again at 1-, 3-, 6-, and 12-month follow-up visits postprocedure.

Data were collected, which included in-hospital deaths and related complications, that is, hemodynamic abnormalities, arrhythmias, device embolization, infective endocarditis, mechanical hemolysis, thrombi, embolism, and residual shunts.

3 | RESULTS

A total of 16 patients (median age 58 years) with calcified PDAs (sizes ranging from 3 to 7 mm) underwent transcatheter closure. The median

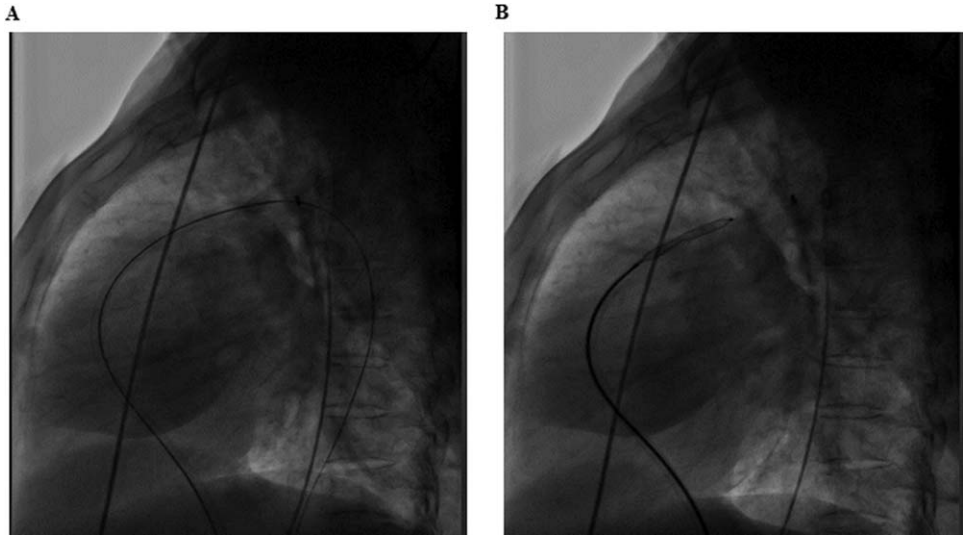

FIGURE 2 The arteriovenous wire loop and duct occluder delivery. A. Arteriovenous wire loop (see details in the Materials and Methods). B. The delivery sheath was directed over the arteriovenous wire loop, through the PDA into the aorta with the distal tip of the delivery sheath pointing to the aortic wall opposite the ampulla

ductus diameter was 4 mm and the median ductus length was 3 mm. The median Qp/Qs was 1.6. Eleven patients (68.8%) had a mean pulmonary artery pressure greater than 25 mm Hg that was reduced immediately after the procedure. The median device size was 6 mm at the pulmonary artery end. All patient demographics and characteristics were summarized in Table 1.

The procedural success rate was 100%. The antegrade approach was used in 11 patients, and the retrograde wire-assisted technique in 5.

There were no deaths. A trivial residual shunt was observed in three patients before hospital discharge. One of these three patients, with a history of hypertension, also had mild intravascular hemolysis. After pharmacological treatment, signs of hemolysis vanished at 7 days post PDA closure. The shunt disappeared in all three patients at 3-month follow-up. There was no new-onset residual shunt, device embolization, device dislocation, infective endocarditis, or embolism during the entire follow-up period. At 1-year follow-up, symptoms, that is, exertional dyspnea, palpitations, and fatigue, disappeared in all but three patients (cases 5, 10, and 14). In all these three patients the pulmonary pressure remained elevated above 25 mm Hg. Although symptoms persisted in these patients (case 5, exertional dyspnea and palpitations; case 10, palpitations; case 14, exertional dyspnea and fatigue), all were improved over baseline.

4 | DISCUSSION

Surgical procedures described for the closure of calcified PDAs are complex and often associated with important complications such as pneumothorax, bleeding, postoperative pain, and recurrent laryngeal nerve palsy.[1,6,7] Transcatheter closure using the Rashkind double umbrella device has been reported in patients with calcified PDAs.[9,10] An issue with the use of the Rashkind device is that after the implantation a significant number of patients, (over 19% at 1-year follow-up) had residual leaks.[13] Use of the Rashkind device was eventually

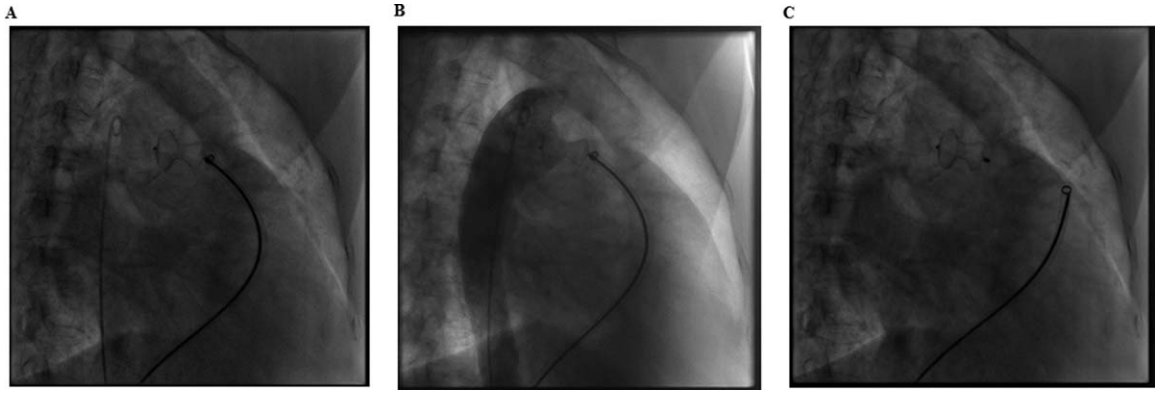

FIGURE 3 Deployment of the duct occluder. A. The duct occluder was opened in such a sequence that the aortic end of the occluder was first opened then the pulmonary artery end. B. Descending aorta angiography showed no residual shunt and the occluder positioned firmly against the PDA. C. Afterward, the occluder was released

TABLE 1 Patient demographics and clinical characteristics

Case no.	Sex	Age (years)	Weight (kg)	PDA type	PDA diameter (mm)	PDA length (mm)	Qp/Qs	PAP (1) (mm Hg)	PAP (2) (mm Hg)	PVR (dyn.s/cm5)	Device size (mm)
1	F	52	74	A	3.5	3	1.5	48/28 (34)	39/18 (26)	271.2	8/6
2	F	57	65	A	4	3.5	1.9	26/14 (22)	21/12 (16)	162.7	8/6
3	F	59	68	A	3	3	1.6	30/13 (19)	24/12 (17)	244.1	6/4
4	M	61	89	B	6	4.5	1.5	53/26 (37)	32/19 (24)	366.1	10/8
5	F	63	66	A	4.5	2.5	1.4	73/32 (52)	54/26 (38)	501.7	10/8
6	F	54	81	A	3	3	2.1	32/21 (25)	26/15 (20)	122.0	8/6
7	F	58	72	A	4	3.5	2.2	46/15 (30)	27/12 (18)	135.6	8/6
8	F	69	64	A	3.5	3	2.9	19/8 (13)	17/8 (12)	142.4	8/6
9	F	55	72	A	4.5	4	1.5	44/20 (29)	37/18 (26)	270.5	10/8
10	F	63	76	A	4	3	1.6	51/29 (40)	42/21 (32)	298.9	10/8
11	F	59	68	A	5	4	2.0	32/18 (25)	24/13 (18)	227.8	10/8
12	F	67	65	A	3.5	3	2.2	25/13 (18)	21/11 (16)	170.8	8/6
13	M	57	76	A	3	3	1.6	33/17 (26)	26/15 (20)	256.3	8/6
14	F	62	81	B	6	2.5	1.5	71/36 (53)	48/21 (36)	541.3	10/8
15	F	57	79	A	4.5	4	1.9	21/10 (16)	19/10 (15)	231.9	10/8
16	F	66	68	A	7	5	1.7	56/25 (41)	42/17 (29)	327.4	12/10

PDA, patent ductus arteriosus; PDA type, the type of ductus determined using the standard Kirchenko classification; Qp/Qs, pulmonary to systemic blood flow ratio; PAP (1), pulmonary arterial pressure before procedure; PAP (2), pulmonary arterial pressure measured immediately after procedure; PVR, pulmonary vascular resistance before procedure.

abandoned due to high rates of significant residual shunts that often required second intervention,[3,9,13] and the lack of benefit over surgical ligation. The ADO is frequently used for transcatheter closure of moderate and large PDAs,[1,5] but their use for the closure of calcified PDAs is rarely reported. In this study, we report the successful closure of calcified PDAs using the duct occluder in adult patients. Calcification reduces the elasticity of the PDA, such that an extra-large occluder may cause chest distress. In view of this possibility, all occluders we chose in this study were approximately 2–3 mm larger than the minimum diameter of the PDA. In our series, we found it difficult to advance the multipurpose catheter through the calcified duct in about one third of patients (5/16). For these patients, the retrograde wire-assisted technique was used to establish the arteriovenous wire loop. When using this technique, in order to reduce the shear stress on the sheath and to avoid sheath kinking which might result in the rupture of calcified plaque, the catheter was not advanced into the descending aorta as done in the antegrade approach. Instead, the catheter was directed in aorta about 2–3 mm, and the device was deployed and released. With this modification, the PDA was successfully closed in all five patients with whom there was difficulty passing the catheter through the duct. Although this technique has not been proven to be more successful because of the lack of appropriate controls, we believe the modified procedure minimizes the disturbance of the calcified tissue.

Using the rim of calcium as a landmark, we found it easy to pull the deployed retention skirt into the aortic ampulla and track the occluder into the ductus. In many cases we also found it difficult to visualize the calcified PDA with a straight lateral view and/or a 30° right anterior oblique view. Therefore, according to the calcified rim of PDA ampulla, a suitable right anterior oblique view (such as 45°) was selected. In this study, a nonstandard angiography view was used in nine patients.

Hemolysis related to a residual shunt usually develops in the first 24 hours postprocedure, but may also occur weeks later.[14,15] Severe hemolysis may result in anemia, jaundice, renal failure, and coagulopathy. In our series, only one patient had mild hemolysis that was successfully managed by pharmacological treatment. Calcification is considered a risk factor for residual aorto-pulmonary flow, as it is difficult for a rigid, calcified PDA to perfectly conform to the device.[9] Therefore, a residual, postprocedure shunt may be more frequently seen in patients with calcified PDAs. Indeed, in our series three patients (18.8%) had a residual shunt that was not clinically significant, and disappeared at 3-month follow-up. Intraoperative identification of potential residual shunt, proper judgment, and experience are very important in order to avoid a second intervention. For a residual-shunt that requires re-intervention in patients with calcified PDA, the coil closure may be the best option, but this was not necessary in our series.

One of the limitations of this study is the small number of patients enrolled. In addition, the advantages of the modified retrograde wire-assisted was not validated in this study.

5 | CONCLUSION

With the use of the antegrade approach when the catheter was directed smoothly through the calcified duct, or the use of retrograde wire-assisted technique when it was difficult for the catheter to pass through the duct, successful closure of calcified PDA with few complications in older adult patients was achieved using the duct occluder.

CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

Gu X, Sun H and Fei J performed the procedure and collected the data. Gu X and Zhang Q analyzed the data and drafted the first manuscript. Kutryk M and Zhang X conceived the research, critically revised and finally approved the manuscript.

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