The clinical application of micro-catheter and micro-guidewire rail technique in transcatheter closure for children with very small patent ductus arteriosus

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Research Article

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Abstract

Objective

Percutaneous closure of the small Patent Ductus Arteriosus (PDA) that a conventional 0.035"hydrophilic guide wire cannot pass through was challenging. A new technique of using a coronary guidewire with microcatheter assistance in the closure of the small PDA via AmplatzerDuctOccluder(ADO) was developed.

Methods

This is a single-center, retrospective study from April 2017 to December 2019, including 12 patients. A 0.014" coronary guidewire (BMW, Abbott, tip load 0.7g) with the assistance of a 1.9F-2.4F catheter was advanced into the PDA. A 4F or 5F delivery system was chosen to deliver the ADOdevice by either an antegrade (venous) or retrograde (arterial) approach with the support of a semi-rail or a full rail: a guidewire-established femoral arteriovenous loop.All patients completed a 6-month follow-up.

Results

Successful PDA closure via this technique in all patients was achieved (n = 15). The average diameter of the PDAs detected by transthoracic echocardiography (TTE) and aortic angiography were1.61 ± 0.53mm (1.00-2.50mm), 0.76 ± 0.83mm (0.50-0.80mm) respectively. No complications were found during the procedure and the follow-up period.

Conclusion

Using a coronary guidewirewith the assistance of a microcatheter to close small PDA is safe and effective, and thereby offers a new opportunity to improve the success rate of percutaneous closure of a PDA.

Introduction

Patent ductus arteriosus (PDA) is one of the common congenital heart diseases with an incidence of approximately 10% in all congenital heart defects[1]. A moderate or large PDA and a small but audible PDA were recommended[2] to be closed percutaneously due to the hazards of pulmonary hypertension, left ventricular overload, risks of infective endarteritis(IE), or risks of pulmonary endarteritis and subsequent pulmonary embolism [3].Percutaneous closure of a PDA has been proved to be a safe procedure with a high success rate. However, there were failure of percutaneous occlusion due to the ductus was too small to be passed through.

Percutaneous coils closure for the small PDAs had been reported[4–6]. Gudausky et al[6] reported a single Gianturco coil was implanted successfully in 28 patients with small PDAs. Nevertheless, the use of coils has some problems, such as residual shunt, coil displacement, embolism, etc.With the introduction of the ADO in 2013, the coils have been replacing by the ADOsince the occluder device has excellent steerability, which is detachable and can be repositioned very precisely. Specific techniques of using ADOto close small PDAs has not been reported yet.

In our study, we developed the technique of microcatheter-assisted percutaneous PDA closure via ADO to improve the success rate of closure

Materials And Methods

Patient Population

This is a retrospective study of patients from April 2017 to December 2019using a coronary guidewirewith the assistance of a microcatheter to close small PDA via the AMPLATZERTM Duct Occluder II (ADO II). All the PDAs were confirmed by transthoracic echocardiography (TTE) before the procedure. Inclusion criteria for this series were: 1)percutaneous PDA closure had been performed; 2)A coronary guidewirewith assisted microcatheter to close the PDA was used.Patients who were unwilling to join the study were excluded.

Interventional protocol

Semi-rail

For patients under the age of 16, the procedure was performed under general anesthesia. Typically, percutaneous access by the Seldinger technique was obtained to a right femoral artery using a 5F(Terumo Corporate, Tokyo Japan)sheath. Angiography was performed in the descending aorta using a 5F pigtail catheter to determine the location, size, and shape of a PDA. The tip of the 0.014" (BMW, Abbott, tip load 0.7g) coronary guidewire with the protection of the1.9F-2.4F catheter (FINECROSS MG, Terumo Corporate) were successively advanced into the PDA by either the retrograde approach (right femoral artery - aorta – PDA – pulmonary artery the right ventricle-right atrium-superior vena cava or inferior vena cava) or the anterograde approach (right femoral vein - inferior vena cava - right atrium-right ventricle – pulmonary artery – PDA – aorta). Thereafter, the semi-rail (without using snare) was established. Under the support of the semi-rail, the 4F or 5F AMPLATZERTM TorqVue Low Profile Delivery System was advancedacross the PDA along the semi-rail. Then the coronary guidewire and the microcatheter were removed and the ADO II was also advanced across the PDA. The PDA was closed from either the aortic side (retrograde approach) or pulmonary side (anterograde approach). Angiography and Color Doppler 2D echocardiography were performed to evaluate the presence of residual shunts and ductal closure after the occluder was released.

Full rail

If the 4F or 5F delivery system is still unable to pass through the narrow part of the ductus for the lack of sufficient support from the semi-rail, a full rail should be established by the femoral vein approach. After puncturing with a 5F puncture sheath, a 5F MPA2 catheter and a snare were introduced into the femoral vein. Snaring the coronary guidewire protected by the microcatheter in the superior vena cava or inferior vena cava established a full rail. The guidewire was not pulled out of the femoral vein. With the support of the full rail, the 4F or 5F delivery system entered the pulmonary artery from the aortic side and then occluded PDA through the femoral artery (retrograde approach). Using the coronary lengthening guidewire technique, the guidewire can also be pulled out of the femoral vein. From the femoral vein, the 4F or 5F delivery system advanced across the ductsfrom the pulmonary artery side. Then the PDA was closed from the pulmonary side (antegrade approach).

2.3 Follow-up

All the patients were performed Chest Xray, TTE, and Electrocardiograph (ECG) at 1 month, 3months, 6monthsafter the procedure.

Results

A total of the 12 children were consented and attempted the ADO II implantation successfully. Children patients' demographics were shown in Table 1. The average diameters of the PDAs detected by TTE and aortic angiography were 1.61 ± 0.53mm(1.00-2.50mm), 0.76 ± 0.83 mm (0.50-0.80mm) respectively.The average lengthof PDAs was 18.9 ± 6.0mm.PDA was classified as type C according to Krichenko type.

The success rate of the procedure was 100%. Anterograde occlusion was performed in 12 cases (5 full-rail, 7 semi-rail). Seven cases required snaring of the coronary wire. The ADO II 3/6mm was mostly used (n = 9), followed by the ADO II 3/4mm (n = 6). The average of Fluoroscopy time (FT) was 6.5 ± 1.6 mins. Details are shown in Table 2. The semi-rail (guidewire and the microcatheter) wasn't dislodged from the PDA when the Delivery System was advanced. No significant pressure gradients in the aorta after the implantation were found. No access related complications including femoral arteriovenous fistula, vascular impinge, rupture of PDAs occurred. No obvious residual shunts, occluder displacement, and/or other complications were foundduring the 6-month follow-up period.

Table 1
Children patients demographics

Variable	Statistics n(%)
Sex	
Females	8
Males	4
Median age (years, range)	3.7 ± 1.5 (2–6)
Median weight (kg, range)	16.4 ± 5.4 (10–26)
Median height (cm,range)	103.1 ± 13.9 (88–130)

Table 2
Procedure details

Patients	Occlusion approach	Snare	ADO type (mm)
1	retrograde	Y	3/4
2	retrograde	N	3/6
3	retrograde	Y	3/6
4	retrograde	N	3/4
5	retrograde	Y	3/4
6	retrograde	Y	3/6
7	retrograde	Y	3/6
8	retrograde	N	3/4
9	retrograde	N	3/6
10	retrograde	N	3/4
11	anterograde	Y	3/4
12	anterograde	N	3/6

Discussion

Using a coronary guidewirewith the assistance of a microcatheter to close small PDA is feasible.The coronary guidewire was used for crossing the atretic valve in patients with pulmonary valve atresia[7]. In our series, a 0.014" coronary guidewire (the diameter is 0.356mm) was used to pass through the PDAs since a conventional 0.035"hydrophilic guide wire was too large. According to our experiences, the use of the low tip load coronary guidewire (0.7g) and the protection from a 1.9F-2.4F catheter (outer diameter

0.627mm-0.792mm) during the advancement of the guidewire were able to avoid valve injury or impingement on vessels.

Traditionally, the extra stiff guidewire was used to offer sufficient support for the delivery system. However, the stiff wire could potentiallylead to perforation or the creation of a false lumen. To avoid the problem,the support during delivering the occluder device was from a coronary guidewire with the assistance of a microcatheter via building a semi-rail or a full-rail. In our study, the semi-rail provided support for the 4F or 5F delivery system via advancing the coronary guidewire with the microcatheter into PDAby either the retrograde approach (shown in Fig. 1A, 1B) or the anterograde approach.The full-rail provided support via building an arterial-venous loop (right femoral artery – aorta - PDA–pulmonary artery–right ventricular–right atrial–superior vena cava or inferior vena cava-femoral vein, shown in Fig. 1C, 1D). If the semi-rail failed to provide sufficient supports (Fig. 2A), the full-rail was built thereafter (shown in Fig. 2B). With the use of the technique mentioned above, we closed all of the small PDAs successfully without complications. A similar technique was used by Haas et al[8]to implant the coronary stent in the PDA for palliation of patients with a truly duct-dependent pulmonary circulation. We assumed this technique will improve the success rates of PDA closure and reduce risks associated with access-related complications.

There are still some safety concerns of the new technique including valve or vessel injury and risks of radiation. Firstly, valve or vessel injury could be avoided in large part by using the soft coronary guidewire with the assistance of the microcatheter. The advancement of the delivery system should be gentle to avoid PDA rupture. Secondly, the FT in the series was 6.5 ± 1.6 min. It has been reported that the mean FT during PDA closure is 8–21 mins. Therefore, the new technique wouldn't extendthe FT. Lifetime attributable risk (LAR) was used to assess the radiation-induced cancer risk. LAR ranges from 0.02 to 13 per 1000 procedures for PDA[9]. Theoretically, the new technique is safer than the traditional technique, which could be used in the occlusion of PDAs with minimum diameter.

The new technique improves the possibilities of closure the very small PDAs technically. On an interventional therapeutic basis, we tried to redefine the very small PDAs as PDAs that could not be passed through by a conventional 0.035"hydrophilic guide wire (the diameter is about 0.889mm). To be clearer, the very small PDAs are PDAs that were less than 1mm under fluoroscopy. However, there are two challenging issues needed to be solved before the wide spread of this new technique in the occlusion of the very small PDAs without a murmur or with an innocent murmur [10–12]. Firstly, the risks brought from PDA closure should not outweigh the risks of IE (0.01%-0.14%) if we leave the very small PDAs open, but the benefits-risks balance is difficult to evaluate precisely. Secondly, even though patients could gain benefits from the procedure, the number Need To Treat to save a child from IE is 300,000[13].

In conclusion, the technique is feasible and safe. the coming of the new technique may improve the success rate of PDA closure. The limitation of this study is the duration of follow-up and only 12 patients were involved. In order to evaluate the efficacy and safety of this new technique, more data are needed.

Declarations

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledge

None.

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Figures

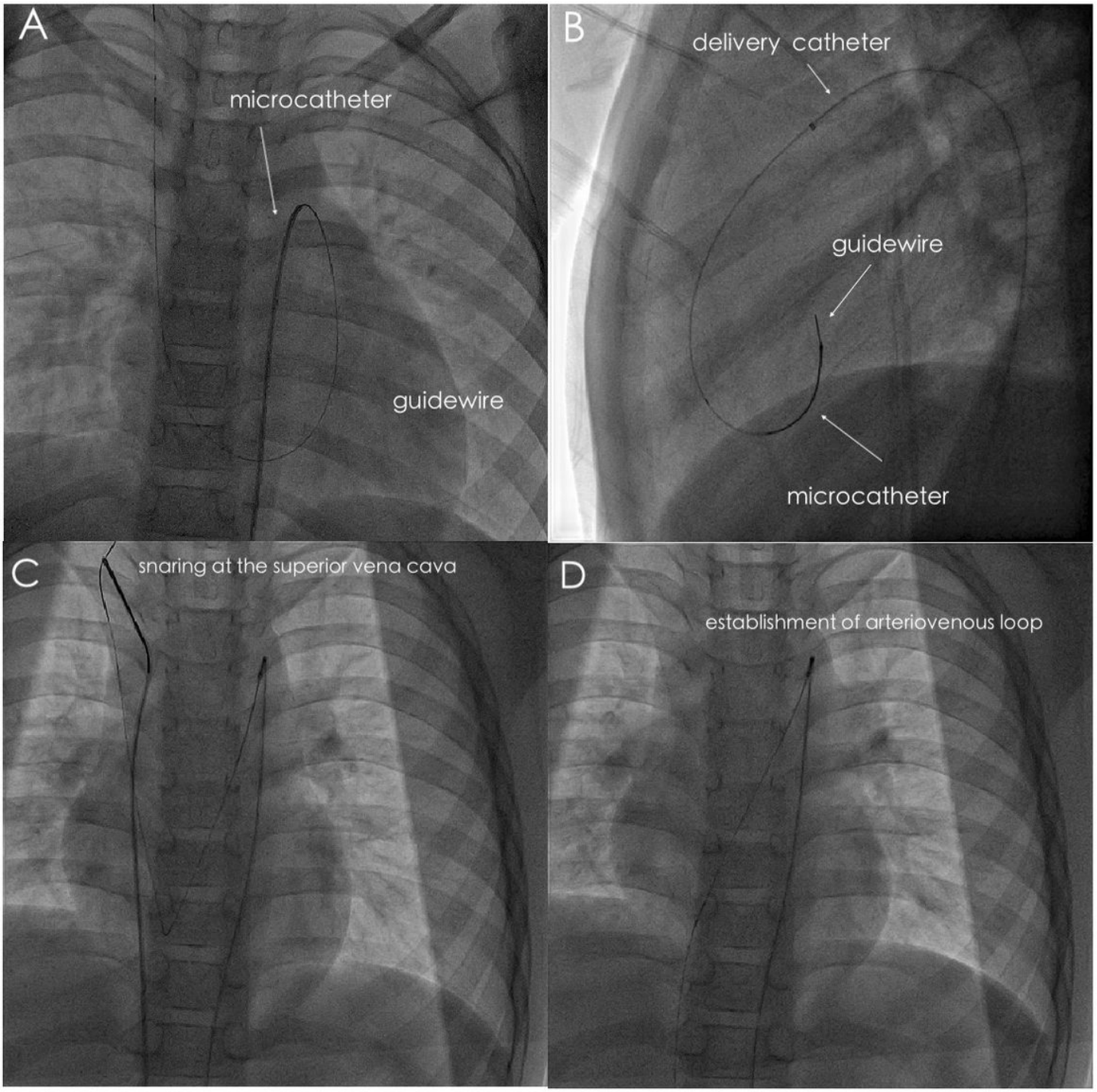

Figure 1

Establishment of the semi-rail and full-rail

A: A microcatheter advanced through a coronary guidewire passing through a PDA; B: A delivery sheath advanced through the semi-rail; C: The guidewire snared at the superior vena cava; D: The full-rail was established.

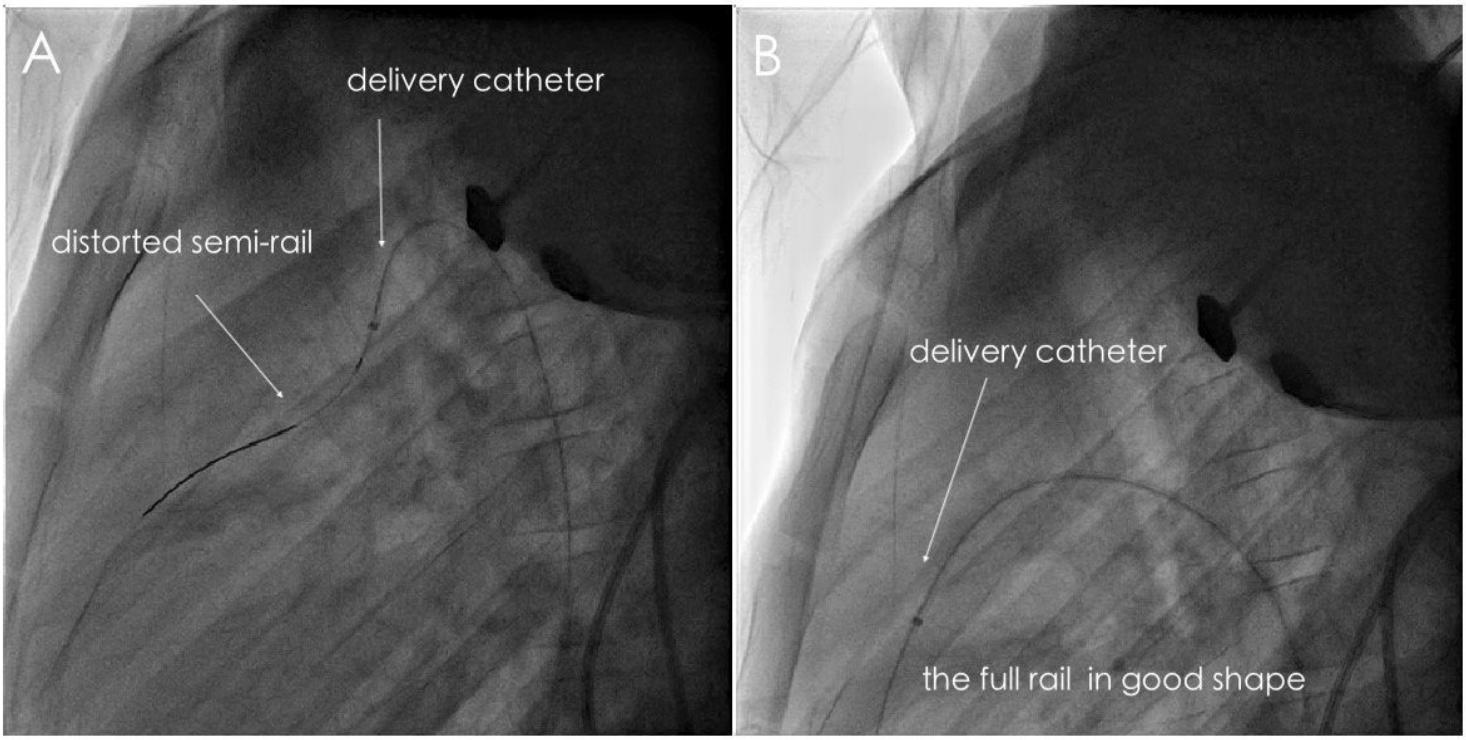

Figure 2

Comparative supports provided by the semi-rail and full-rail

A: The semi-rail was distorted by the delivery system due to its inadequate support; B: The delivery system was supported by the full-rail.