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Treatment of Recoarctation after Catheter Intervention for Aortic Coarctation Using a Balloon-Expandable Stent Graft within a Self-Expanding Stent Graft

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Abstract

We successfully treated re-coarctation following balloon angioplasty for aortic coarctation in an 11-year-old girl using a novel sequential stent grafting approach. A self-expanding stent graft was first deployed, followed by the implantation of a balloon-expandable stent graft within the initial stent. This strategy ensured optimal luminal expansion and minimized vascular stress. The patient had previously undergone balloon angioplasty at age 9, but restenosis developed. After the staged stent grafting at age 11, the pressure gradient across the lesion was reduced from 60 mmHg to 10 mmHg, with no procedural complications. To the best of our knowledge, no prior reports have described this technique. We believe this method offers a promising option for the management of similar complex re-coarctation cases.

Keywords: Coarctation of aorta; Stent implantation; Stant graft

Introduction

Coarctation of the aorta (CoA) is a congenital narrowing of the aortic lumen that accounts for 5–8% of all congenital heart defects, with a prevalence of approximately 0.4 per 1,000 live births. Among its subtypes, native coarctation of the aorta is the most common form diagnosed in infancy and childhood [1]. The first surgical repair of CoA was performed by Crafoord and Nylin in 1944, involving resection of the stenotic segment and reconstruction via end-to-end anastomosis. For several decades thereafter, surgery remained the only therapeutic option [2]. In 1982, Singer et al. introduced balloon angioplasty (BA) as a less invasive alternative, which rapidly gained widespread acceptance due to its safety and efficacy [3]. However, BA was associated with notable complications, such as re-coarctation and aneurysm formation. To address these limitations, stent implantation has emerged as an effective and durable treatment modality, particularly in older children and adolescents. Reports on stent therapy for aortic coarctation (CoA) have primarily focused on the use of bare-metal stents (BMSs); [4-6] however, in recent years, the application of stent grafts (SGs) has gained traction due to their potential advantages [7,8].

The development of small-diameter SGs has further facilitated their use in clinical practice. Herein, we present the case of an 11-year-old girl who underwent treatment for re-coarctation following prior catheter-based therapy for CoA. She was successfully treated using a self-expanding SG (Gore® VIABAHN® Endoprosthesis, WL Gore & Associates, Flagstaff, AZ, USA), followed by a balloon-expandable SG (VIABAHN® VBX Endoprosthesis, WL Gore & Associates, Flagstaff, AZ, USA). Although SGs have been used for CoA, no prior reports have described this specific technique. Given the promising results in this case, we aim to contribute to the existing literature by detailing this approach.

Case Presentation

An 11-year-old girl was diagnosed with CoA and patent ductus arteriosus (PDA) during the neonatal period. Her medical history also included congenital esotropia, intestinal malrotation, ectopic ureteral opening, a left renal artery anomaly, and left renal artery stenosis. Due to symptomatic PDA, surgical ligation was performed at 40 days of age, while mild CoA was managed conservatively.

Although she remained asymptomatic, the CoA progressed over time, and at age 9, an attempt at balloon dilation (BD) was made. However, the procedure was ineffective, as recoiling and further narrowing were observed. By 11 years of age, severe CoA was detected via echocardiography, accompanied by left ventricular hypertrophy, necessitating stent placement. Preprocedural computed tomography (CT) (Figure 1) revealed a minimum coarctation diameter of 3.5mm with a small adjacent aneurysm. Additionally, significant collateral circulation via the internal thoracic and intercostal arteries was noted.

Upon admission, the patient was classified as New York Heart Association (NYHA) Class II. Physical examination revealed warm extremities with remarkable cardiac auscultation. However, the dorsalis pedis pulses were difficult to palpate. Her blood pressure was 160/85 mmHg in the right upper limb and 130/70 mmHg in the right lower limb, indicating a systolic blood pressure gradient of approximately 30 mmHg. Laboratory investigations showed no abnormalities.

Treatment Strategy and Methods

A multidisciplinary team, including pediatric cardiologists, cardiovascular surgeons, and interventional radiologists, developed the treatment plan. Given the tortuosity of the vessel and the presence of a small aneurysm, we opted for a self-expanding SG (VIABAHN®), followed by a balloon-expandable SG (VIABAHN® VBX) to ensure optimal luminal expansion while minimizing vessel wall stress.

Under general anesthesia, a 5 French sheath was inserted into the right femoral artery, and a 4 French short sheath was placed in the left femoral artery. A 5-Fr pigtail catheter was used to perform an ascending aortogram, which confirmed the stenotic segment and guided stent placement planning. Significant collateral flow was observed through the subclavian artery branches, with a pressure gradient of approximately 60 mmHg across the coarctation.

A 0.035-inch \guidewire (Terumo Corporation, Tokyo, Japan) was inserted and exchanged for an extra-stiff guidewire (Amplatz Super Stiff™, Boston Scientific, Marlborough, MA, USA). A 10-Fr sheath was advanced, followed by pre-dilation using a 5.0 × 40 mm balloon catheter (MustangTM, Boston Scientific, Marlborough, MA, USA). A 6.0 × 50 mm VIABAHN® Endoprosthesis was deployed, ensuring that it did not overlap the left subclavian artery (Figure 2A). Subsequently, a VIABAHN® VBX was deployed within the self-expanding SG and inflated to 8 atm, achieving optimal luminal expansion (Figure 2B and 2C).

Following the procedure, the pressure gradient across the coarctation decreased to 10 mmHg. Aortography confirmed adequate stent expansion without any signs of dissection (Figure 2D). Hemostasis was achieved using a closure system (Perclose® ProGlide™, Abbott Vascular, Santa Clara, CA, USA). A follow-up angiogram confirmed satisfactory femoral artery flow. The patient was extubated without complications and returned to the ward.

Calcium channel blockers resolved postoperative paradoxical hypertension within a day. The patient was discharged without further complications, based on the 1-month follow-up CT scan (Figure 3). The patient remained asymptomatic, attended school, and continued treatment with calcium channel blockers and angiotensin-converting enzyme (ACE) inhibitors for hypertension due to renal artery stenosis.

Figure 1: Contrast-Enhanced Computed Tomography (CT) Imaging of aortic arch. Pre-procedural contrast-enhanced CT scan showing the narrowest segment of the aortic coarctation measuring 3.5 mm in diameter. A small aneurysm (red arrow) is visible adjacent to the stenotic site.

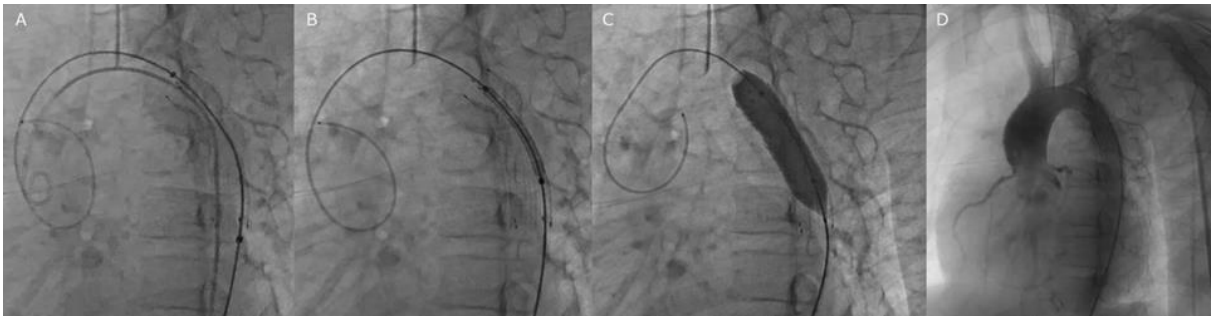

Figure 2: Deployment of the Second Stent Graft and Post-Deployment Aortography.

(A) The initially deployed self-expanding stent graft left a residual stenotic segment at the coarctation site.

(B) A balloon-expandable stent graft was inserted within the previously deployed stent graft.

(C) Balloon expansion was performed to optimize luminal diameter.

(D) Post-deployment aortography confirmed that the aortic curvature was preserved, and the stenotic segment was no longer observed.

Figure 3: Contrast-Enhanced Computed Tomography (CT) of the Thoracic Great Vessels 1 Month Postoperatively.

Follow-up contrast-enhanced CT performed 1 month after the procedure showed no evidence of stent-graft migration, aneurysm formation, or endoleaks. The residual stenotic segment measured 12 mm in diameter but was deemed hemodynamically insignificant.

Discussion

We successfully treated re-coarctation following balloon angioplasty using a self-expanding SG (VIABAHN® Endoprosthesis) followed by a balloon-expandable SG (VIABAHN® VBX). Conventionally, BMSs are used for CoA stenting. A mid-term study involving 104 patients with CoA treated with BMSs reported vascular wall injuries in 11 cases [9].

Although BMS remains a well-established approach, vascular injury remains a concern and often necessitates SG placement. The literature on SG use for CoA remains limited. A study using the Cheatham-Platinum stent in 30 patients (with 33 stents implanted) reported only minor complications, including one case of femoral artery aneurysm and two cases of access-site hematomas. No complications were observed after 11 months. Comparative studies have not confirmed the superiority or inferiority of SG over BMS.

In the present case, the SG insertion was performed using a 10-Fr sheath, which offers a notable advantage over larger sheath-dependent devices, such as the Cheatham Platinum Stent (NuMED Inc., Hopkinton, NY, USA), the Advanta V12 covered stent (Getinge, Wayne, NJ, USA), and BeGraft aortic stent (Bentley InnoMed, Hechingen, Germany). Our method involved the initial deployment of a self-expanding SG, followed by a balloon-expandable SG. VIABAHN® is highly flexible, preserving vascular curvature. Although a BMS could have been placed within the self-expanding SG, its rigidity might have led to vascular straightening and increased risk of vascular injury. Instead, we selected the flexible VIABAHN® VBX, allowing controlled expansion while maintaining the vessel's natural curvature. This technique produced satisfactory results while preventing complications related to excessive straightening.

To the best of our knowledge, no previous reports have described this specific approach for CoA. Given its advantages, we believe this technique warrants further consideration. Long-term data are needed to evaluate its durability and efficacy. The patient remains under ongoing follow-up, and further research is necessary to determine the long-term clinical benefits of this approach.

Conclusion

In this case, sequential implantation of a self-expanding stent graft followed by a balloon-expandable stent graft effectively treated re-coarctation after failed balloon angioplasty, ensuring optimal luminal expansion while preserving vascular integrity. This technique offers a promising option for the management of complex re-coarctation cases, although further studies are needed to validate its long-term outcomes.

Author Contributions

All authors contributed equally to the treatment planning and actively participated in the actual treatment. They also contributed to data collection. Authors A.K. and W.K. were responsible for drafting the manuscript.

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