Balloon angioplasty of aortic coarctation in critically ill newborns using axillary artery access

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ABSTRACT

Balloon angioplasty may be performed as the first treatment of aortic coarctation to stabilize newborns too sick for immediate surgery. The issue of vascular access is the key to the successful treatment of critical newborns. In our study, we argue that the lesser-known axillary access route is the safest and most effective route of vascular access for balloon angioplasty in infants with aortic coarctation. To support this argument, we present the case of eight unstable newborns with complex heart diseases, who were successfully treated with percutaneous intervention through the axillary artery. This case series is followed by an analysis of the greater efficacy of this technique compared to the more conventional femoral and carotid routes. We conclude by acknowledging the substantial advantages of this lesser-known vascular access and advocate its more widespread clinical implementation in the treatment of critical newborns.

Keywords: Aortic coarctation, axillary artery access, balloon angioplasty, critical newborns

INTRODUCTION

Aortic coarctation accounts for 5%–7% of live births with congenital heart disease[1] with an incidence of approximately 3/10,000 births.[2] The current standard treatment for infants and young child with native aortic coarctation is surgery, but in selected cases, balloon angioplasty may be performed, as a palliative strategy to stabilize neonates unable to undergo urgent surgical treatment due to severe clinical impairments.[3]

This percutaneous intervention is typically carried out via femoral access, but in the case of low-body-weight children, the preferred route is through the carotid artery, a technique that presents fewer risks and technical difficulties. However, the carotid artery approach presents several potential complications, as it requires surgical isolation by a cutdown procedure. A favorable alternative to these traditional techniques is the lesser-known axillary artery access, a vascular route that has seldom been described in the literature to date.[4-7]

We present a series of ten consecutive urgent balloon angioplasties of aortic coarctation in critically ill newborns and infants with attempted axillary artery access. The aim of our study is to raise awareness about this viable alternative route for vascular access in the setting of urgent balloon angioplasty of coarctation in patients with high surgical risk.

CASE REPORTS

In our center, ten consecutive patients were treated, between 2012 and 2018, with urgent balloon angioplasty for aortic coarctation. For eight of these patients, the procedure was performed via axillary artery access. The preprocedural characteristics of the patients are

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summarized in Table 1. The median age at procedure was 30 days (range: 2–390 days), with a median weight of 2.65 kg (range: 1.7–5.6 kg). Six patients were born early term and two (cases 3 and 7) were siblings. All patients presented with native aortic coarctation, with the exception of one patient who had been previously treated with patch aortoplasty for a hypoplastic aortic arch and who presented recurrent stenosis at repair site (case 5). With the exception of the latter, all patients were critically ill infants at presentation who showed clinical signs of low cardiac output and congestive heart failure and presented nonpalpable femoral pulses. Blood gas analysis showed various degrees of lactic acidosis, while echocardiography demonstrated severe isthmic coarctation with distinctive antegrade diastolic flow across the descending aorta at continuous-wave Doppler analysis. With the exception of case 5, left ventricular dilation and systolic dysfunction was reported [Figure 1]. Due to the severe clinical and hemodynamic impairment, patients were scheduled for urgent balloon angioplasty rather than surgery.

To best expose the axillary artery, the patient's head was turned leftward and the right arm was extended in a head-up position. After definition of the puncture site by finger palpation, using the Seldinger technique, the artery was punctured with a 21-gauge needle. The needle was advanced infirm and short jabs, rather than with a continuous and slow motion, to avoid an ease dislocation of the artery, as it is surrounded only by soft tissues. After obtaining a free flow of arterial blood, a 0.014″floppy guidewire was advanced to limit any vascular damages and intimal dissections, and then, an atraumatic 4-F sheath was slid over the wire.

While cannulation of the axillary artery was feasible for eight out of the ten patients, two patients (case 9 and 10) were treated with a carotid artery approach, after two failing attempts of percutaneous puncture to the right axillary artery. A cardiovascular surgeon isolated the right common carotid artery by a cutdown procedure and performed an arteriotomy, inserting a 4-F sheath directly into the artery.

Contrast was injected directly into the axillary artery through the sheath, and the angiography revealed invariably severe aortic isthmic coarctation [Figure 2].

With the exception of case 8, a 5-20 mm 65 cm Tyshak-Mini balloon (NuMED, Inc., Hopkinton, NY, USA) was advanced over a 0.014″ floppy guidewire across coarctation and was inflated twice to the pressure level recommended by the manufacturer until relief of the waist was seen. For case 8, the patient with the lowest body weight, we chose a 4-20 mm balloon according to aortic dimensions.

Angiographic and pressure gradient control demonstrated an effective angioplasty for every case with the exception of case 5. In this patient, two additional inflations were carried out with balloons of increasingly greater diameter, respectively, a 6-20 mm and a 7-20 mm balloon. The

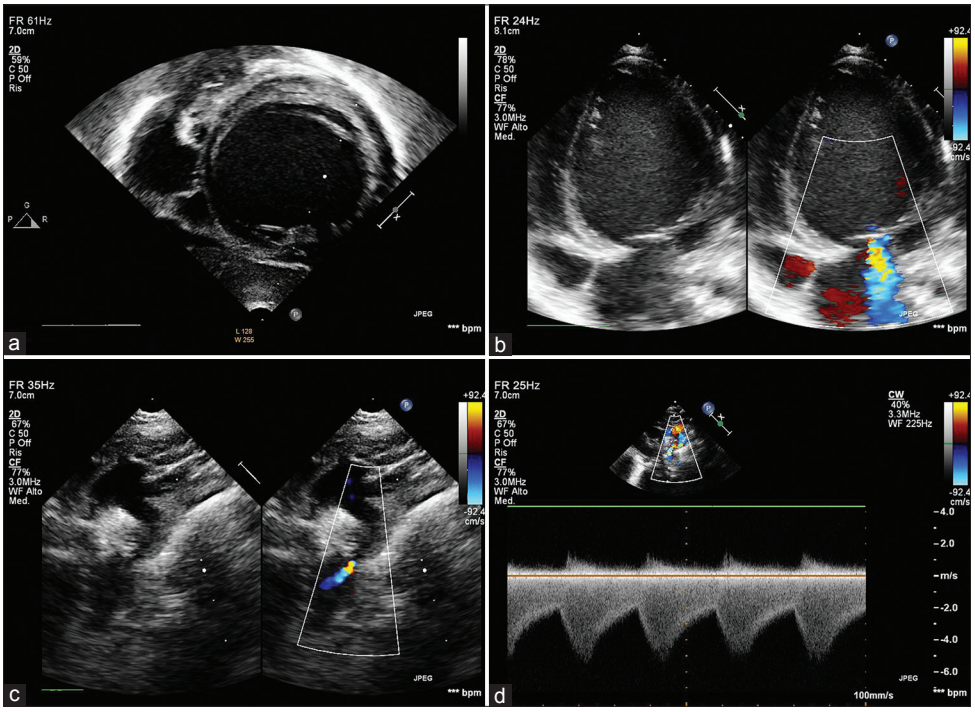

Figure 1: Echocardiography imaging. Subcostal short axis view of the ventricles: left ventricle appears severely dilated (a). The apical four-chamber view shows a functional moderate-to-severe mitral regurgitation (b). Suprasternal window displays a narrow isthmic aortic coarctation (c). Continuous-wave Doppler reveals a 5.3 m/s maximum velocity across coarctation, with typical anterograde diastolic runoff (d)

final pressure gradient was 10 mmHg, and the following aortography showed a good procedural result.

Hemostasis was always effectively achieved with careful digital compression at the puncture site for at least 30 min, as long as the arterial bleeding was completely stopped.

Only two complications were documented: an aneurysm at the site of angioplasty (case 7) and a brief episode of bradycardia, immediately resolved with atropine (case 6).

All eight patients treated via axillary artery access are alive. Follow-up data are summarized in Table 2. After a median follow-up period of 4.05 years (interquartile range: 1.09–5), two patients experienced recurrent aortic coarctation, both repaired with patch aortoplasty. Aortic aneurysm at the isthmic site of angioplasty was detected in one case.

DISCUSSION

In neonates and infants, aortic coarctation has the common clinical pattern of congestive heart failure and has a poor prognosis if left untreated.[8] In our case study, the patients presented a severe clinical status and hemodynamic decompensation; therefore, a prompt percutaneous resolution was chosen over a high-risk surgery. Aortic coarctation with congestive heart failure in neonates and infants carries high surgical risk. Low birth weight and prematurity are well-acknowledged risk factors for mortality in infants with congenital heart disease.[9] Although percutaneous treatment of aortic coarctation in neonates and infants remains controversial due to the occurrence of residual or recurrent stenosis and aneurysm formation at the dilation site,[10] urgent balloon dilation can diminish mortality, providing a bridge to surgery for severely ill patients.[11]

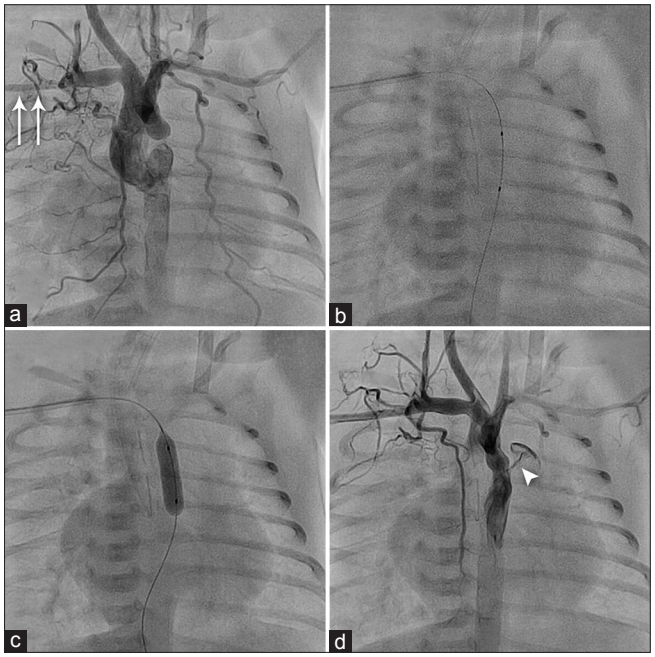

Figure 2: Percutaneous intervention. (a) Anterior–posterior views. Axillary artery was cannulated with a 4-F sheath (arrows), and aortography confirmed a severe aortic coarctation. Aortic isthmus was effectively crossed (b) and balloon angioplasty was performed (c). Following aortography showed good procedural result (d) and showed patency of a little ductus arteriosus (arrow-heads)

Table 1: Patients' characteristics at the time of the procedure

	Sex/age	Weight at procedure (kg)	Aortic arch hypoplasia	Concomitant CHD
Case 1	Female/2 months	3.6	No	None
Case 2	Female/1 month	2.3	No	BAV
Case 3	Female/4 months	4.7	No	None
Case 4	Female/10 day	2.9	No	VSD+MS
Case 5	Male/4 months	5.6	Yes	Bov Arch
Case 6	Male/13 months	5.5	Yes	BAV
Case 7	Male/2 days	2.4	No	None
Case 8	Female/1 month	1.8	No	None
Case 9*	Male/7 days	1.9	Yes	None
Case 10*	Female/14 days	2.7	No	None

*Patient treated via carotid artery approach. BAV: Bicuspid aortic valve, Bov Arch: bovine aortic arch, CHD: Congenital heart defects, MS: Congenital mitral stenosis, Recur: recurrent, VSD: Ventricular septal defect

Table 2: Follow-up data

	Follow-up period (year)	Late complications	Further procedures (time to procedure)	Medical treatment
Case 1	5	None	None	None
Case 2	5	None	Aortic valvuloplasty (2 months)	Beta-blocker
Case 3	5	None	None	Beta-blocker
Case 4	4.6	None	None	ACE-i
Case 5	3.5	None	None	Beta-blocker
Case 6	2.6	Re-CoA	Patch aortoplasty (2 months)	ACE-i
Case 7	1	Re-CoA; local aneurysm	Patch aortoplasty (2 months)	Beta-blocker
Case 8	1	Re-CoA	Patch aortoplasty (6 months)	Beta-blocker

ACE-i: Angiotensin-converting Enzyme inhibitor, Re-CoA: Recurrent aortic coarctation

As a result of the successful interventions described in our case series, we aim to highlight the technical and clinical advantages of using an axillary artery access over a more commonly used carotid route in performing urgent balloon angioplasty in critical neonates and children with aortic coarctation. Few descriptions of axillary artery access for percutaneous interventions in children can be found in the literature. Davenport *et al.*[4] described that all alternative vascular routes are generically used to perform pediatric interventional cardiac catheterization at their center, including axillary artery access. Dua *et al.*[5] reported good feasibility and acceptable safety of the transaxillary approach for balloon valvoplasty in infants with aortic stenosis. Only Schranz and Michel-Behnke[6] and Nişli *et al.*[7] provide descriptions of successful aortic coarctation balloon angioplasties via axillary artery access.

In our experience, the axillary artery access route was feasible in 80% of cases and did not present any technical limitation, even for critically ill patients with a low cardiac output. The success rate would have been even higher using ultrasound guidance, as showed in the series by Htet *et al.* for axillary artery catheter in critically ill patients, obtaining a success rate of 96%.[12] Axillary access route led to successful percutaneous interventions, even when aortic coarctation was associated with hypoplasia of the aortic arch. Moreover, it demonstrated to be a safe approach and no major and minor local complications were reported except for one case of a local aneurysm at the site of angioplasty.

Not only is this technique easier to employ in the case of aortic coarctation but also displays many technical advantages. First, the axillary pulse is easier to feel in smaller patients, especially in premature neonates and in particular in the presence of critical aortic coarctation, when femoral pulses are not palpable. Moreover, the axillary route proves critical in the case of concomitant low cardiac output due to failing left ventricle, which could make finding a femoral pulse even harder. Second, femoral artery trauma and occlusion remains an additional concern, especially in neonates. Thrombus formation is not reversible with heparin or tissue-type plasminogen activator and can result in irreversible occlusion of the femoral artery, potentially causing a growth impairment of the ipsilateral leg.[10] On the other hand, the axillary artery is not an end artery and thus, when cannulated, arm perfusion is still guaranteed by the second intercostal artery and the acromial artery.[6] Nevertheless, vascular flow abnormalities (such as loss of arterial pulse) following cardiac catheterization using axillary artery access have been described by Viswanathan *et al.*[13] and should be taken into account in the long term follow-up, although in the cited series, the axillary artery access was obtained by a surgical cutdown and clinical signs of arterial insufficiency were not reported.[13] Finally, the axillary access unlike the carotid artery approach does not need a surgical cutdown and repair.[14]

To establish whether the axillary approach could be considered as a safe and effective alternative to femoral and carotid routes, a larger prospective controlled study should be conducted, preferably in multiple centers so as to overcome the limitations inherent to a study on the treatment of aortic coarctation, namely its relatively low incidence rate and the current practice of treating young patients with this condition with a surgical procedure.

CONCLUSION

The axillary artery access route for percutaneous balloon angioplasty of aortic coarctation in critical newborns can be considered a viable alternative to the femoral or carotid artery approach. According to the experience of our catheterization laboratory, it demonstrated to be always safe and feasible, even in smaller critical newborns with concomitant low cardiac output, in whom femoral approach would have been more challenging.

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Conflicts of interest

There are no conflicts of interest.

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