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Short communication

Primary coronary stent implantation is a feasible bridging therapy to surgery in very low birth weight infants with critical aortic coarctation

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ABSTRACT

Background: Surgical treatment of critical aortic coarctation (CoA) is difficult in very low birth weight (VLBW) infants ≤1500 g and preferably postponed until 3 kg with prostaglandins (PGE).
Objectives: To investigate the procedure and outcome of primary coronary stent implantation as bridging therapy to surgery in VLBW infants with CoA.
Methods: Retrospective evaluation of primary CoA stenting in VLBW infants from 2010 to 2015.
Results: Five VLBW infants with a median gestational age of 29 weeks (27–32) underwent primary CoA stenting. Indication was cardiac failure in 4 and severe hypertension in 1 patient. Age and weight at intervention were 14 days (range 12–16) and 1200 g (680–1380), respectively. Stent diameter ranged 3–5 mm. The femoral artery used for intervention was occluded in all infants without clinical compromise. Severe restenosis and aneurysm occurred in 1 VLBW infant and was successfully treated with covered coronary stents. Median age at surgical correction was 200 days (111–804) and weight 5500 g (4500–11,400). No reinterventions were required during a median postoperative follow-up of 2.8 years (0.1–5.0). Neurodevelopmental outcomes were normal and comparable between patients and siblings (4/5 gemelli).
Conclusions: Primary coronary stent implantation in VLBW infants with critical CoA is a feasible bridging therapy to surgery.

1. Introduction

Severe coarctation of the aorta (CoA) is a critical congenital heart disease (CHD) of the newborn with a prevalence of 4.4 per 10.000 live births [1]. Surgical treatment is the therapy of choice in infants above 3000 g of weight. In newborns below 3000 g initial therapy consists of intravenous prostaglandins (PGE) to keep the arterial duct (PDA) and the ductal tissue in the CoA open until surgery can be safely performed. In very low birth weight (VLBW) infants (≤1500 g) earlier treatment is sometimes warranted due to systemic hypoperfusion, pulmonary hyperperfusion and/or hypertension. Options for treatment include surgery [2–5], percutaneous balloon dilatation [6–11] and percutaneous stent implantation [12,13]. We reviewed our results of primary stent implantation as bridging therapy to surgery in VLBW infants with a critical CoA in whom PGE had to be discontinued.

2. Methods

A tertiary single centre retrospective study was performed at the Wilhelmina Children's Hospital, University Medical Center, Utrecht, The Netherlands. We identified VLBW infants (≤1500 g) with critical CoA (in whom PGE treatment was ineffective) that underwent primary CoA stenting as bridging therapy to surgery between 2010 and 2015. Clinical, procedural and follow-up data were collected and analysed of all eligible patients. The need for informed consent was waived by the local medical-ethical committee.

Femoral artery access was obtained using Seldinger technique with a 26 gauge intravenous cannula (Neoflon, Helsingborg, Sweden) and a 0.014 Teflon tipped coronary guidewire (Pilot 50 Hi-Torque, Abbott, Diegem, Belgium). After switching to a 3 French sheath (Balt, valved introducer, Montmorency, France) a biplane angiography was done with manual contrast injection of 1.5 cm^3 Omnipaque 300 (300 mg/ml, GE, Chalfont St Giles, UK). Anatomic as well as extrathoracic landmarks were used to identify the level of the CoA and the origin of the left subclavian artery. Since there was aortic arch hypoplasia in all patients coronary stent diameter was based on the diameter distal to the CoA. The stent was deployed in one step to its nominal diameter and postdilated to the

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rated burst pressure to achieve maximal diameter, with effective diameter 10% larger than nominal. Surgical correction was performed after adequate growth and at adequate weight by median thoracotomy with longitudinal stent incision and patch plasty.

3. Results

Five VLBW neonates were diagnosed with critical CoA and underwent primary coronary stent implantation as bridging therapy to surgery (Table 1, Fig. 1). There were no non-cardiac comorbidities such as interventricular haemorrhage or sepsis. All neonates had absent femoral pulses, needed mechanical ventilation and received intravenous PGE. Under PGE infusion the arterial duct remained open in 2 (dose 10–20 ng/kg/min) and did not re-open in 3 infants (dose 50–100 ng/kg/min). PGE was not effective in reducing CoA gradient. Indication for primary stent implantation was cardiac failure in 4 and severe brachiocephalic hypertension in 1 patient. Since 4 out of 5 patients had decreased LV-function the invasive gradient over the CoA was considered of minor importance and was only measured in 2 patients (median 42.5 mm Hg, range 40–45). Median effective stent diameter was 4.4 mm (range 3.3 to 5.5) and median stent length was 15 mm (range 9 to 20). Two children received a second coronary stent due to residual stenosis proximal to the first implanted stent (Online Supplement Fig. 2). The maximal balloon inflation pressure necessary to open the CoA and the hypoplastic segment proximal to the CoA was 12 atm (range 10 to 14). Aortic wall integrity and unrestricted perfusion of the LSA was proven in all patients immediately after stent implantation without dissection or aneurysm formation. Only patient 5 had a small residual gradient of 10 mm Hg after stent implantation. Median procedural time was 135 min (range 65 to 160) with a fluoroscopy time of 19 min (range 14 to 26). Median total radiation dose was 75 cGy∗cm^2 (range 15 to 169) and 73 (range 22 to 122) cGy∗cm^2/kg. There were no complications during the procedures. LV-function normalized in all patients during the first two weeks after the intervention. Patient 2 developed an early restenosis and severe aneurysm which was successfully treated with covered coronary stents at an age of 80 days and a weight of 2400 g. At follow-up, the femoral artery used for intervention was occluded in all infants without clinical compromise. All 5 children received uncomplicated surgical correction by median thoracotomy with longitudinal incision of the coronary stent(s) and aortic patch plasty. Surgery was performed at a median age of 200 days (range 111 to 804) and weight of 5500 g (range 4500 to 11,400) (Online Supplement Fig. 3). No relevant recoarctations occurred during a median postoperative follow-up of 2.8 years (range 0.1 to 5.0). Neurodevelopmental quotients (Griffiths scales) at a median age of 18 months were normal (median 105, range 96–113) and comparable with their siblings (4/5 gemelli) (median 115, 96–115).

4. Discussion

In 5 VLBW infants ≤1500 g with critical CoA we demonstrated that primary coronary stent implantation is a feasible and minimally invasive treatment that successfully normalizes haemodynamics and adequately postpones corrective surgery.

Current evidence for the treatment of CoA in VLBW infants is limited. Primary surgery has been reported in 44 newborns with CoA at a median age of 17 days (4–58) and weight of 1600 g (545–2000). Although these studies demonstrated the feasibility of surgical correction, the reported rates of reintervention (34%) and mortality (18%) were very high [2–5] (Online Supplement Table 2). Percutaneous balloon dilatation can be considered as an alternative to surgery and has been described in 11 VLBW neonates at a median age of 14 days (2–34) and weight of 850 g (460 to 1500) [6–11] (Online Supplement Table 3). However, recoarctation does occur in up to 50% of infants treated with balloon dilatation before 6 months of age [14,15]. Percutaneous stent implantation has only been reported in 4 VLBW infants with a median age of 10 days (range 5 to 37) and weight of 1120 g (range 1050 to 1500) at intervention [12,13]. Our study is the first to report on successful stent implantation in patients below 1000 g (2 patients 680 g). In addition, postponement to surgery was longer (median 184 versus 120 days) and weight at surgery was higher (median 5500 versus 4800 g) when compared to previous studies (Online Supplement Table 4).

Although PGE infusion is the first choice and initial treatment to gain weight and postpone surgery, it was unsuccessful in all of our patients. In two patients (patients 1 and 4) the arterial duct remained open but no change in CoA was observed leading to cardiac failure and severe brachiocephalic hypertension respectively. In the other three patients (patients 2, 3, 5) the arterial duct did not re-open and primary stent implantation was indicated because of cardiac failure with low systemic output.

In previous studies reporting on primary balloon dilatation and stent implantation in VLBW infants vascular access varied and included umbilical approach ($n = 5$), femoral artery ($n = 1$), carotid artery (n = 1), femoral vein (n = 1), femoral artery surgical cutdown ($n = 2$) and carotid artery surgical cutdown (n = 5) [6–13] (Online Supplement Tables 3 and 4). In all of our patients femoral artery access was performed. Post-intervention all infants had occlusion of the femoral artery but developed sufficient collaterals without clinical compromise during follow-up (e.g. no discrepancies in leg length observed). Umbilical artery access was no longer available in our population at the time of intervention. Carotid artery access was not performed to avoid possible risks on carotid

Table 1
Results.

Pt	GA (*weeks*)	Age at diagnosis (*days*)	LVF (*FS%*)	PDA with PGE	Indication stent	Age at stent (*days*)	Weight at stent (*gram*)	Diameter pre/post CoA (*mm*)[a]	Stent type[c]	Stent size nominal (*mm*)	Interval to surgery (*days*)	Weight at surgery (*gram*)	CWd before stent/after stent/ pre-op (*m/s*)	FU (*years*)	NDO (*DQ*)
1	28	0	17	Yes	CF	8	680	1.9/3.7	Pro kinetic	5 × 15	322	6800	3.5/1.9/2.3	5.0	110
2	27	2	9	No	CF	12	680	2.6/2.9	Integrity	3 × 9	792	11,400	4.0/2.5/6.2	0.1	NM
3	29	15	26	No	CF	16	1200	2.7/5.6	Pro kinetic [b] Pro Kinetic	5 × 15 5 × 20	184	5500	3.0/1.3/2.5	1.4	113
4	32	0	36	Yes	SH	16	1200	3.0/4.8	Driver	4 × 15	162	4500	3.7/2.0/4.0	2.8	99
5	31	12	5	No	CF	14	1380	2.1/3.3	Pro kinetic [b] Skylor	4 × 13 4 × 13	97	5300	3.8/1.5/3.8	4.1	96
Med[d]	**29**	**2**	**17**			**14**	**1200**	**2.6/3.7**		**4 × 15**	**184**	**5500**	**3.7/1.9/3.8**	**2.8**	**105**

CF = cardiac failure, CWd = continuous wave Doppler, DQ = developmental quotient, FS = fractional shortening, FU = follow-up after surgery, GA = gestational age, LVF = left ventricular function, Med = Median, NDO = neurodevelopmental outcome, NM = not measured, PDA = patent ductus arteriosus, PGE = prostaglandin, Pt = patient, SH = severe hypertension.

[a] Measured biplane during systole.

[b] Second coronary stent placed due to residual pre-stent stenosis.

[c] Driver (Medtronic, Minneapolis, USA), Integrity (Medtronic), Pro Kinetic Energy (Biotronik, Berlin, Germany), Skylor (INVAtec, Roncadelle, Italy).

[d] Values Med represents the median. This line can be deleted if the editors find this more approriate, the additional value is very limited.

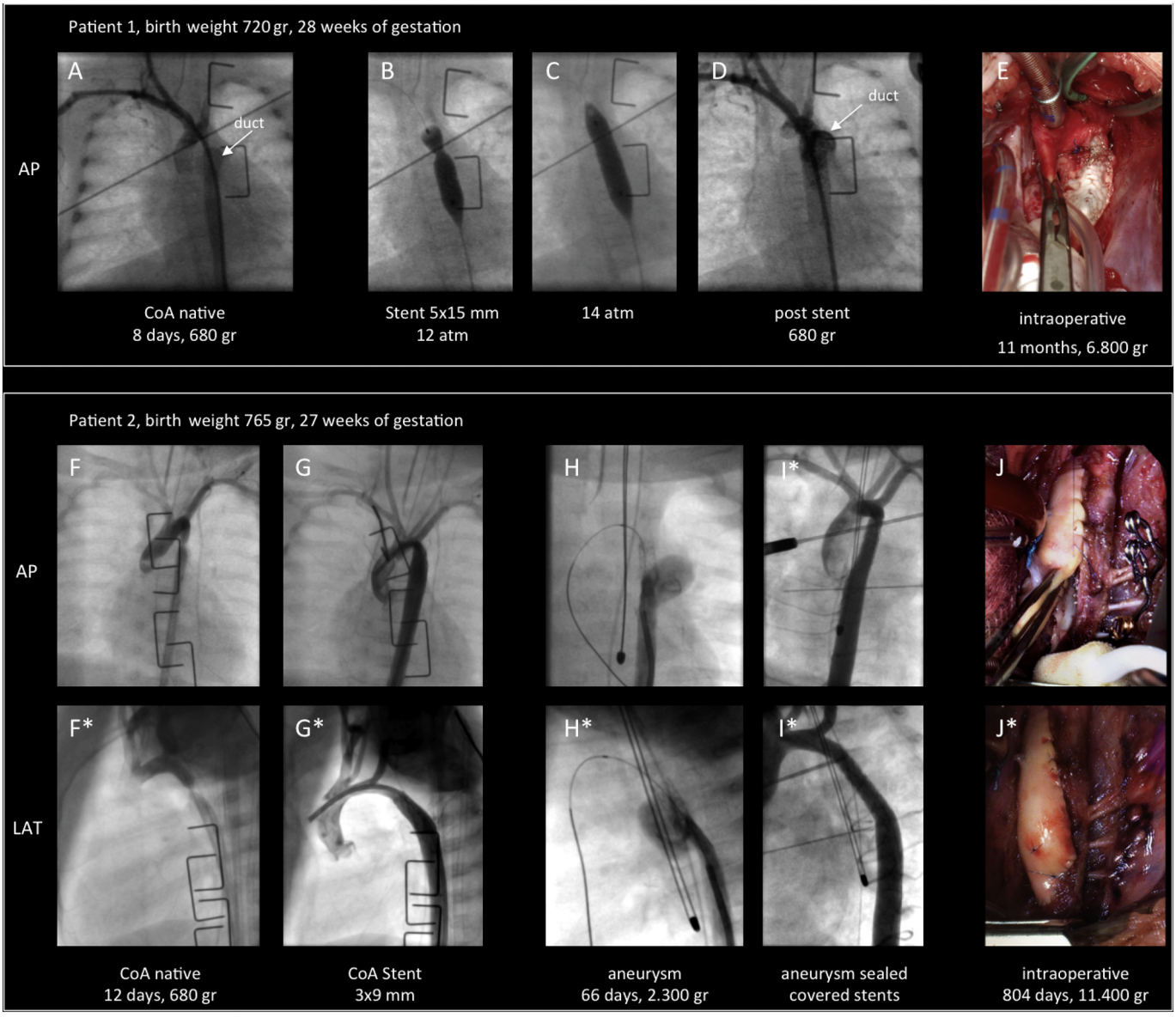

Fig. 1. Frontal plane views interventional steps, intraoperative image patient 1 and biplane views of interventional steps, aneurysm sealing, intraoperative images patient 2. A) Native CoA, arrow indicates open duct. B, C) Stent placement and subtotal deployment at 12 atm and total deployment at 14 atm. D) Result after primary stent implantation. E) Intraoperative image with longitudinal incision of the coronary stent showing endothelium and stent struts before patch plasty. F, F*) Native CoA with tubular arch hypoplasia, duct closed. G, G*) Status post primary stent implantation. H, H*) Large aneurysm (15 × 8 mm) 66 days later. I, I*) Angiography after aneurysm sealing with covered coronary stents. J, J*) Intraoperative images after longitudinal incision of the coronary stent showing patch plasty with homograft tissue.

trauma or cerebral embolism in these small vessel patients. Recent data show that surgical cutdown [16] and percutaneous [17] carotid artery access are relatively safe alternatives to percutaneous femoral access in neonates and infants. However, carotid artery thrombosis has been observed in these series with unknown effects on brain injury and outcome. More studies are needed to properly outweigh risks and benefits of these different vascular approaches.

Since all of our patients had hypoplastic segments proximal to the CoA, target stent diameters were based upon the diameter distal to the CoA. These stent dimensions provided an adequate bridging interval to surgery with a sufficient weight at the time of the operation (Online Supplement Figs. 2 and 3). One patient (patient 2) developed an early recoarctation and severe aneurysm which was successfully treated with covered coronary stents. This was probably caused by the increased aortic wall stress through the relatively small diameter (3 mm) and short length (9 mm) of the stent. Since the stents in all patients were cut longitudinally and left in situ during surgery, a recoarctation will likely occur in the future. However, reinterventions can probably be postponed until percutaneous intervention with adult size stents can be performed.

5. Conclusions

Primary coronary stent implantation in VLBW infants with critical CoA is a feasible therapy which offers a significant bridging-to-surgery when prostaglandin therapy fails. This two-step strategy resulted in lower rates of mortality and recoarctation in comparison with primary surgery or primary balloon dilatation and offered normal neonatal and neurodevelopmental outcome in this series of VLBW infants.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcard.2018.03.009.

Conflict of interest

There is no conflict of interest. Only Gregor J. Krings has disclosures: consultant Edwards, consultant Medtronic and member of the advisory board of Siemens.

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