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Systemic Blood Pressure After Stent Management for Arch Coarctation Implications for Clinical Care

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Objectives The goal of this study was to prospectively assess blood pressure (BP) and echocardiographic parameters to delineate the incidence and nature of the hypertension burden in this cohort.

Background Few data are available on the long-term outcomes of aortic stenting.

Methods Thirty-one patients with successfully stented coarctation during childhood (mean age 12.4 years) underwent 24-h ambulatory BP monitoring (ABPM), exercise BP measurement, and echocardiographic assessment.

Results Mean time after stent implantation was 5.3 ± 4 years. Hypertension was noted on one-off right-arm BP assessment in 3 patients (10%), but on the basis of the 24-h ABPM assessment in 14 patients (45%). Twenty-four of 31 patients (80%) had an abnormally elevated exercise BP response. Peak exercise BP correlated with left ventricular mass index ($r = 0.51$; $p < 0.05$), which was also significantly increased in the entire cohort (mean = 91.3 g/m^2; $p < 0.05$). In patients with significant somatic growth since implantation, the indexed diameter of the stent (to aortic diameter) had significantly decreased from the 48th percentile at the implantation to the 4th percentile during the study ($p < 0.05$). There was no difference in any parameter between patients with native or those with recurrent coarctation.

Conclusions Hypertension is endemic in patients with stented coarctation, irrespective of the absence of residual obstruction. Due to abnormal BP homeostasis, hypertension should be aggressively pursued by ABPM assessment and exercise stress testing in this population. Relative hypoplasia of the stented arch after somatic growth may contribute to this tendency and should provoke consideration of elective serial redilation of coarctation stents. (J Am Coll Cardiol Intv 2013;6:192–201) © 2013 by the American College of Cardiology Foundation

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Coarctation of the aorta (CoA) accounts for 5% to 8% of all congenital heart lesions presenting in infancy (1). Since the first surgical correction in 1944, numerous treatment strategies have been described and tested to relieve the arch obstruction (2,3). In the last 2 decades, percutaneous approaches have attained clinical prominence with excellent short-term clinical outcomes (3–6). A comprehensive understanding of the pathophysiology after arch repair, in regard to intrinsic systemic vascular abnormalities and blood pressure (BP) homeostasis is in its infancy. Multiple studies have shown abnormal responses to exercise in all age groups whether addressed surgically or by stent or balloon dilation. However, the clinical significance of these abnormal responses has not been fully characterized (7–12).

Although several authors have assessed resting, ambulatory, and exercise BP response, few studies have prospectively assessed a cohort to determine the longer-term impact on cardiovascular physiology (13,14). Thus, the goals of this study were first to delineate the incidence of hypertension through analysis of multiple BP parameters at medium- to long-term follow-up after successful stent implantation, and second, to identify patient and treatment characteristics that may be associated with an increased hypertensive burden.

Methods

Study design. One hundred ten children were identified from the cardiac interventional database that had stent implantation for CoA at age <18 years, between September 1995 and November 2009. Indications for stent implantation were a cuff systolic upper-to-lower limb BP gradient of >20 mm Hg with angiographic confirmation of the lesion, either a recurrent (reCoA) or so-called native (naCoA) obstruction in the isthmus region of the aorta. From this population, 41 children had a previous surgical repair with reCoA and 69 had an naCoA. Sixteen patients were excluded; 4 who were <8 years of age and not felt to be able to cooperate with the exercise protocol; 8 due to complex intracardiac anatomy; and 4 due to a physical disability that disallowed formal exercise testing (ET). Of the remaining 94, 11 patients were not contacted because they lived outside of Ontario, 18 could not be contacted, and 28 patients did not wish to participate in the study. Two patients had hemodynamically insignificant intracardiac abnormalities considered not to influence the study, along with 15 patients with bicuspid aortic nonstenotic valves. Thirty-seven patients agreed to participate in the study. Of these, 6 patients failed to attend their appointments. As such, 31 patients were recruited to participate in the study, which included clinical and echocardiographic assessment, ET and BP assessment, and 24-h ambulatory blood pressure monitoring (ABPM). One patient who had ABPM monitoring failed to attend the exercise component of the protocol. Surgical and interventional details, including angiography, were reviewed to define arch measurements following the most recent intervention, specifically the minimum stent diameter and compared with published normative data (15). Invasive gradients and follow-up arm and leg BPs were documented to determine procedural success. The study was approved by the institutional review board and the research ethics committee, and informed, written consent was obtained from all subjects.

Resting and exercise BP measurement and echocardiographic assessment. Resting BPs were measured with a GE Dinamap ProCare system (Critikon, Tampa, Florida), immediately before a standardized recumbent bicycle staged exercise study. Resting BP was recorded as an average of 2 readings taken from the right arm sitting, over a 5- to 10-min period immediately before exercise, and from the noncatheterized leg. All femoral pulses were easily palpable. Echocardiographic examinations were performed by 2 experienced cardiac sonographers, using a Vivid 7 echocardiographic system (GE Corp., Wauwatosa, Wisconsin) with probe frequencies selected as appropriate for patient size. A full baseline echocardiographic study was performed before exercise according to our clinical standard coarctation protocol, which includes apical 4-chamber, parasternal short-axis, and parasternal long-axis views, acquired according to published guidelines. Left ventricular mass was calculated according to the Devereux formula and indexed to body surface area. After the baseline echocardiographic study, an exercise study was performed on a reclining bike (Lode, Groningen, the Netherlands). During exercise, peak gradients were recorded through the stented aorta using continuous-wave Doppler techniques.

Abbreviations and Acronyms

ABPM = ambulatory blood pressure monitoring
BP = blood pressure
BSA = body surface area
CoA = coarctation of the aorta
ECG = electrocardiography
EIH = exercise-induced hypertension
ET = exercise testing
LVMI = indexed left ventricular mass
MASBP = mean ambulatory systolic blood pressure
naCoA = native coarctation
reCoA = recurrent coarctation

BP measurement, electrocardiography (ECG), and stress echocardiographic assessment was then performed on a semirecumbent cycle ergometer during progressive exercise in incremental stages. Bicycle pedaling was begun at 25 W and increased by 25 W every 2 min with the right arm BP taken every 2 min during exercise using the Dinamap system. The test was either symptom-limited (fatigue, chest pain, ECG changes) or when the target heart rate (defined as 80% of the maximal heart rate for age) was reached.

An abnormal systolic BP response to exercise (exaggerated absolute rise) or exercise-induced hypertension (EIH), was defined using published normal adult and pediatric values as appropriate (see Results) (16–22). During exercise,