

## Transcatheter Treatment for Native Aortic Coarctation in Adult (with and Without Stenting)

Sadiq Al-Hamash \*, Zuhair Al-Nasiry\*\*, Mahdi S. Alzaidi\*\*\*, Abd Al-Ameer A. Al-Amiry\*\*\*\*

### ABSTRACT:

#### BACKGROUND:

Surgical repair was considered the conventional treatment for native aortic coarctation while balloon angioplasty emerged recently as an alternative to surgical repair and considered the treatment of choice in recurrent postoperative coarctation but its use with or without endovascular stent implantation for native coarctation remains controversial.

#### OBJECTIVE:

We sought to investigate the results of transcatheter treatment for native aortic coarctation in adults and compare the success rates and early complications rates between balloon angioplasty and self expandable stent.

#### METHOD:

Fifty one patients with native coarctation underwent transcatheter intervention in two different cardiac centers in Baghdad between January 2001 and July 2004, 26 patients underwent balloon angioplasty alone while 25 patients had endovascular stenting for coarctation. Hemodynamic, angiographic and follow up data were reviewed and analyzed for each patient.

#### RESULT:

The procedure acutely reduced the transcoarctation systolic pressure gradient from  $68 \pm 23$  to  $7.5 \pm 11$  mmHg with increase in minimal luminal diameter of coarct segment more than two folds post intervention. The immediate success rate was comparable in stent and balloon group (88% versus 84% respectively). Nearly half of our patients became normotensive without antihypertensive medication before discharge. Minor complications found to be significantly higher among balloon group as compared to stent group 34% versus 28%.

#### CONCLUSION:

Balloon angioplasty with or without endovascular stenting is safe and effective non-surgical approach for native aortic coarctation in adult. Larger sample size and longer follow up are needed.

**KEYWORDS:** coarctation, angioplasty, stent

### INTRODUCTION:

Coarctation of aorta is a narrowing of aorta usually in the region of the ligamentum arteriosum. It may be discrete or tubular or associated with hypoplasia of the aortic arch and isthmus<sup>(1)</sup>. It was first described by Prussian anatomist Johann Friederich Meckel in the 1760<sup>(2)</sup>.

The first surgical repair was performed by Crafoord in 1944<sup>(3)</sup>. In 1982 Lock et al performed balloon dilatation on surgically excised coarctation lesions, confirming the feasibility of dilatation, at the same year Singer et al described a successful balloon dilatation of recoarctation after surgical repair in a critically ill neonate and in 1983 Lababidi described a successful dilatation of native coarctation in an infant with cardiac failure<sup>(3)</sup>.

It has been estimated that if patients with isolated coarctation left untreated, up to 90% will die before 50 years of age as a result of acute or chronic heart failure, bacterial endocarditis, aortic rupture or dissection, intracranial hemorrhage, hypertension, premature coronary

\* Department of Pediatric, College of Medicine- Baghdad University.

\*\* Ibn Al-Bitar Center for Cardiac Surgery, Baghdad.

\*\*\* Ibn-Albitar Center for Cardiac Surgery, Baghdad.

\*\*\*\*, Ibn Al-Bitar Center for Cardiac Surgery, Baghdad.

artery diseases and valvular heart disease<sup>(5)</sup>. Surgical repair is considered the conventional treatment for native aortic coarctation<sup>(6)</sup>. It has improved the prognosis for patients with this malformation, although the long term result after coarctation repair may not be completely satisfactory<sup>(7)</sup>. Recently percutaneous balloon angioplasty with or without endovascular stent has been used as an alternative to surgical repair. Balloon angioplasty appears to be effective in recurrent post operative coarctation and is now considered the treatment of choice for this condition. The use of balloon angioplasty with or without balloon expandable stent for native coarctation however is more controversial<sup>(8)</sup>.

### AIM OF THE STUDY

- 1- To evaluate the result of balloon angioplasty with and without endovascular stent in native aortic coarctation in adult
- 2- To compare the immediate success rate and early complication rate between balloon angioplasty and self expandable stent in the treatment of native aortic coarctation

### PATIENTS AND METHODS:

Between January 2001 and July 2004, 51 patients with coarctation of aorta underwent balloon angioplasty in two cardiac centers in Baghdad, Ibn Albitar Cardiac Center (26 patients without stenting) and Iraqi center for heart disease (25 patients with direct stenting with post stenting balloon dilatation).

Data regarding patient clinical status such as age, sex, weight, surface area, associated cardiac defects, and antihypertensive treatment were collected from medical records in each center.

Only patients older than 18 years with native discrete coarctation & significant pressure gradient ( $> 20$  mm.Hg) were included in the study. Patients with isthmus or aortic arch hypoplasia were considered non candidate for angioplasty.

The patient was defined as hypertensive when the systolic blood pressure was more than or equal to 140 mm Hg with or without diastolic blood pressure more than or equal to 90 mm. Hg. The cardiac catheterization and angiographic data were reviewed for peak to peak systolic pressure gradient above and below the areas of coarctation before and after intervention, also the diameter of the isthmus, coarctation site and the descending aorta at the level of diaphragm were measured before intervention and the coarctation

segment diameter after intervention was also recorded. All measurement were corrected for magnification using the known diameter of the angiographic catheter

The procedure considered successful when the peak to peak pressure gradient across the coarctation segment is less than 20 mm.Hg immediately after the intervention<sup>(11)</sup>.

Regarding the complications in this study minor flap or tear were defined as thin mobile membrane extending into the wall over not more than a quarter of circumference of the aorta while all other more extensive lesions were classified as major dissection<sup>(3)</sup>.

### RESULTS:

Fifty one patients with native aortic coarctations proved by cardiac catheterization study, 26 patients treated by ballon angioplasty alone and 25 patients with direct stenting, were included in the study. The mean age at time of intervention was  $26 \pm 8$  year (range 18-54), and the male to femal ratio was 3 to 1.

Forty seven patients (92%) had hypertension, the remaining on time checking were normotensive. The majority has discrete coarctation (86.3%) while tubular type was present in seven patients (13.7%) only. Nearly half of our patients had associated cardiac defects (complex coarctation). There was no statistically significant difference in baseline characteristics, pre interventional angiographic and hemodynamic data between stent and balloon group. Tab 1

The procedure acutely reduced the peak to peak systolic coarctation gradient from  $(68 \pm 23)$  to  $(7.5 \pm 11)$  mmHg after intervention ( $p = 0.0001$ ). The systolic pressure in ascending aorta reduced significantly from  $(166 \pm 30)$  to  $(137 \pm 27)$  mmHg ( $p = 0.0001$ ). The minimal luminal diameter of coarct segment increased more than two fold post intervention from  $(7.3 \pm 2.3)$  mm to  $(16 \pm 3)$  mm ( $p = 0.0001$ ). The systolic pressure in the descending aorta raised significantly also from  $(99 \pm 20)$  to  $(120 \pm 4)$  mmHg ( $p = 0.001$ ). On the other hand there was no statically significant difference in post procedural angiographic and hemodynamic changes between stent and balloon group. Table 2.

The procedural success rate was slightly higher in stent group as compared to balloon group. But it didn't reach statistical significance (88% versus 84%). Tab 3

Using multiple logistic regression analysis studying the predictor of success, the regression

## TRAETMENT OF AORTIC COARCTATION

model showed that balloon to aorta ratio and type of coarctation are the only factors that affect success rate of the procedure while others such as age , sex , coarctation diameter, balloon size, and ascending aorta systolic pressure didn't affect the success rate of the procedure .

More than one third of our patients with coarctation were severely hypertensive on two or more antihypertensive drugs before intervention. This was reduced to only 5.9 % after the procedure (p=0.001) .Tab 4

**Table 1: Base line characteristics of both Stent and Balloon group**

Item	Stent	Balloon	P-value
Age (yrs)	28+/-9	23+/-7	0.07
Weight(kg)	66+/-15	63+/-9	0.39
Height(cm)	164+/-13	160+/-10	0.28
Body surface area(m2)	1.6+/-0.27	1.6+/-0.13	0.73
Male	19	19	0.53
Female	6	7	0.65
Hypertension	24	23	0.6
Lv dysfunction	2	3	0.65
Discrete coarctation	21	23	0.5
Tubular coarctation	4	3	0.75
Isolated coarctation	16	10	0.15
Complex coarctation	9	19	0.12
Ascending aorta peak syst. mmHg)	170+/-28	163+/-32	0.39
Descending aorta peak syst.	98+/-21	101+/-19	0.52
Pressure gradient across coarctation	72+/-24	65+/-21	0.27
Coarctation diameter(mm)	8+/-2	6.5+/-2.3	0.11
Balloon size(mm)	19+/-1.9	17+/-3	0.12
Balloon /aorta ratio	1+/-0.9	0.95+/-0.1	0.18

**Table 2: Angiographic and hemodynamic data pre and post procedure**

Parameter	Preprocedure	Postprocedure	p-value
Ascending aorta peak systolic pressure ( mmHg)	166+/-30	137+/-27	0.0001
Descending aorta peak systolic pressure ( mmHg)	99+/-20	120+/-44	0.001
Pressure gradient mmHg	68+/-23	7.5+/-11	0.0001
Coarctation diameter (mm)	7.3+/-2.3	16+/-3	0.0001

## TRAETMENT OF AORTIC COARCTATION

**Table 3: Post procedure Angiographic and hemodynamic data in stent and balloon group**

Parameter	Stent	Balloon	p-value
Ascending aorta peak systolic pressure ( mmHg)	139+/-27	153+/-27	0.87
Descending aorta peak systolic pressure ( mmHg)	111+/-55	129+/-29	0.14
Pressure gradient mmHg	9+/-14	6+/-8	0.34
Coarctation diameter (mm)	16+/-3	15.6+/-2.9	0.70

**Table 4: Comparison of blood pressure state pre and post intervention**

Item	Preintervention	Post intervention
Normotensive	4 (8%)	29 (56.9%)
Hypertensive 1	28 (54.8%)	19(37.2%)
Hypertensive 2	19(37.2%)	3 (5.9%)
Total	51 (100%)	51(100%)

P-value 0.0001

**Table 5: Early post-procedural compliations in both stent and balloon groups**

Type of complication	Stent group	Balloon group
Vascular access	2	2
Minor intimal tear	0	5
Prolong chest pain	1	1
Slipped stent	4	0
Paradoxical hypertension	0	1
Total	7 (28%)	9 (34%)

p-value 0.021

### DISCUSSION:

In this study coarctation of aorta was more common in men than women with a male to female ratio of three to one .This is similar to previously reported studies <sup>(1,9)</sup>.

The immediate hemodynamic and angiographic results after balloon dilatation with or without stent implantation were favorable. Post dilatation gradient less than 20 mmHg were obtained in 84% and 88 % of patients in balloon and stent group respectively. Large series of studies reported a comparable initial results after balloon angioplasty with or without stent implantation <sup>(6,9, 11, 13, 14)</sup>. McCrindle et al reported the acute result of 422 balloon dilatation for native aortic

coarctation performed in 25 institutions, success rate ranged bewteen 78-91 % <sup>(3)</sup>.

Data from the adult congenital heart diseases clinic at the Toronto general hospital showed that stent implantation for isolated coarctation has demonstrated a gradient reduction to less than 10 mmHg and normalization of upper limb blood pressure in the majority and many were able to reduce or eliminate antihypertensive medications <sup>(3)</sup>.

We found that ,greater ratio of balloon to aorta diameter and discrete type of coarctation were the only factors that affected the rate of procedural success .This is in agreement with

Ovaert et al who reported that a greater ratio of balloon to aorta diameter was independently associated with early success<sup>(15)</sup>.

Regarding the effect of intervention on BP control, our study showed that the blood pressure was normalized without antihypertensive therapy in 29 patients (57%).

Only 43% of patients remained on antihypertensive drugs and those who need two or more antihypertensive drugs were reduced significantly from 19 patients(37%) to three patients only (5.9%) after interventions( $p=0.0001$ ). These findings concur with the report by Schrader et al<sup>(16)</sup> who reported 79 % rate of normalization of blood pressure after coarctation angioplasty in adolescents and adults. The higher rate of normalization of blood pressure in this study as compared with our study was probably because the mean age at time of intervention of this study was younger than that in our study .Wells et al reported 46% rate of normalization of hypertension after repair in adult<sup>(17)</sup>.

Regarding Complications in our study, there was no periprocedural or early post procedure death in both stent and balloon group. This is comparable to some large studies where no acute mortality related directly to the procedure has been described<sup>(3)</sup>. Regarding minor complications, it was significantly higher among balloon group as compared to stent group 34% versus 28% respectively  $p=0.02$ . This can be explained from studying table 5 which showed minor tear greater in balloon group, expected finding due to mechanical injury to the intima and media of the aortic wall at site of coarctation by inflated balloon which is unavoidable especially in a very severe coarctation.

In all these 5 patients with intimal tear, coarctation diameter before intervention was less than five mm. In those patients with most severe obstructive lesions, there appear to be more invagination of the wall from the media rather than intraluminal shelf which could be enlarged through dilatation (tearing) within the shelf<sup>(3)</sup>.

Four cases of slipped stent had been described in this study because of direct stenting was used in most of our patients (80%) without predilatation. This made the stent to be released over the narrowed segment liable for forward or backward slipping from narrowed to the dilated segment. This can be prevented by predilatating the

coarctation segment prior to stenting to make the narrowed area more suitable for stent deployment or use of balloon mounted stent instead of self expandable stent.

Vascular access complication was the third most important complication in this study, it have been reported in up to 19% of patients in other studies<sup>(19,20)</sup>.

It is related probably to the use of a large vascular sheath especially with a stent deployment . this type of complication is preventable with further improvement in size, contour of angioplasty catheter delivery system and by use of arterial sheaths of acceptable size and or use of recently introduced closure devices( angioseal and vasoseal) for sealing the puncture site at the end of the procedure .

On the basis of these data, we are optimistic that transcatheter aortic balloon angioplasty with or without endovascular stent deployment offers an acceptable alternative to surgical repair, it also offers a significant advantage regarding mortality rate and avoiding intubations, general anaesthesia and thoracotomy, it minimizes blood loss and shortens the duration of hospitalization considerably.

### CONCLUSION:

Balloon angioplasty with or without endovascular stenting is safe and effective non-surgical approach for native aortic coarctation in adult. Larger sample size and longer follow up are needed.

### REFERENCES:

1. Therrien J. :Congenital heart disease in adult. in: Braunwald E, Zips D, Libby P.(eds).Braunwald's Heart disease, 6th ed, Philadelphia, Saunders Elsevier , 2001:1600.
2. Perloff JK. Coarctation of aorta. in:Perloff JK (ed).The Clinical Recognition of Congenital Heart Disease. 5<sup>th</sup> ed, Philadelphia; Saunders, 2003:113.
3. Ovaert C, Benson L, Nykanen D, Freedom R. Transcatheter treatment of coarctation of aorta: A Review . *Pediatr cardiol* 1998;19:27-44.
4. Celermajor D, Greaves K. Survivors of Coarctation Repair: Fixed but not cured. *Heart* 2002;88:113-14.
5. Campbell M. Natural History of coarctation of aorta. *Br Heart J* 1970;32:633-40.

## TRAETMENT OF AORTIC COARCTATION

---

6. Beekman R, Rocchini A, Dick M, Snider A, Crowley D et al. Percutaneous Balloon Angioplasty For Native Coarctation of Aorta. *J Am Coll Cardiol* 1987;10:1078-84.
7. Hellenbrand W, Allen H, Golinko R, Hagler D, Lutin W, Kan J. Balloun angioplasty for aortic coarctation: Results of Valvuloplasty and angioplasty of congenital anomalies Registry. *Am J Cadiol* 1990;65:793-97.
8. Friedman W, Silverman N. Congenital Heart Disease in Infancy and Children. In: Braunwald E, Zipes D. Libby P.(eds).Braunwald's Heart Disease. 6th ed, Pheladilphia; Saunders Elsevier , 2001: 1542.
9. Majwal T. Self expandable stenting of aortic Caorctation in adult. *Am Coll Cardiol* 2002;39: Suppl(9) B.
10. Chobanian A, Backris G, Black H, Green L, Jones D et al. The seventh Report of the Joint National Committee on Prevention, Detection, evaluation and treatment of High Blood Pressure. *JAMA* 2003;289:2560-72.
11. Hamdan M, Maheshwari S, Fahey J, Hellenbrand W. Endovascular stent for coarctation of the aorta: initial results and intermediate term follow up. *J Am Coll Cardiol* 2001;38: 1518-23.
12. Little W. Assessment of normal and abnormal cardiac function, in: Braunwald E, Zipes D. Libby P. (eds).Braunwald's Heart Disease .6th ed, Pheladilphia; Saunders Elsevier, 2001: 493.
13. Fletcher SE, Nihill MR, Grifka RG. Mullins CE. Balloon angioplasty of Native Coarctation of aorta: Midterm follow up and prognostic factor *J Am Coll Cardiol* 1995;25:730-4.
14. Rao PS. Long term follow up Result after balloon dilatation of pulmonic stenosis, aortic stenosis and coarctation of aorta: A review. *Progress in Cardiovascular disease* 1999;42:59-47.
15. Ovaert C, McCrindle B, nykanen D, McDonald C, Freedom R, Benson L. Balloon Angioplasty of Native Coarctation: Clinical outcome and Predictor of success. *J Am Coll Cardiol* 2000;35:988-96.
16. Schrader R, Bussman WD Jacobi V, Kadel C. Long term effect of balloon Coarctation Angioplasty on Arterial Blood Pressure in adolescent and adult patients. *Cathet cardiovasc diagn* 1995;3 6:220-25. [Medline Abstract].
17. Wells WZ, Prendergast TW, Berdiis F,et al .Repair of coarctation of aorta in adult. The fate of systolic hypertension..*Ann Thorac Surg* 1996;61:1168-1171.[Medline Abstract].
18. Fawzy M, Sivanandam V, Galal O, Patel A, Rifai A et al. One to Ten year follow up Results of balloon angioplasty of Native Coarctalion Of aorta in Adolescents and Adults. *J Am Coll Cardiol* 1997-30:1542-46.
19. Burrows PE,Benson LN, Williams WG,Trusler GA,Coles JG. Iliofemoral arterial complication of ballon angioplasty for systemic obstruction in infant and children. *Circul* 1990;82:1868-71.
20. McCrindle BW,Jones,Tk,Morrow WR, et al. Acute results of ballon angioplasty of native coarctation versus recurrent aortic obstruction are equivalent. *J Am coll Cardiol* 1996;28:1810.