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Research

In-hospital outcome of surgical and interventional procedures performed in coarctation of the aorta in 5-25 year old patients

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ABSTRACT

To determine short-term (in-hospital) outcome and complications of surgical and interventional procedures performed for patients with coarctation of the aorta (CoA) in the age range of 5 to 25 year. Medical records of 64 patients (48 males and 16 females) with CoA who underwent surgical treatment March 2002 to March 2012 were reviewed. Surgical operation was done for 26 patients and interventional procedures were done for 18 cases. The data gathered included type of CoA, anatomic type, hospitalization duration, and complications occurred during hospitalization such as hypertension, persistent CoA, surgical wound infection, and death. Both surgery and interventional procedures restored pre-operative hypertension significantly. The safest method regarding in-hospital complications was balloon angioplasty (1 patient had systemic hypertension after the procedure, 25%) followed by Dacron patch (3 cases had hypertension and one patient had persistent coarctation). However, no significant difference was observed between different surgical and interventional procedures. Pre-operative systolic blood pressure, age group, peak systolic gradient, simple or complex CoA, discrete or segmental CoA had no significant relationship with in-hospital complications/outcome. In conclusion, we suggest considering all aspects of patients with CoA to choose the best surgical treatment. Based on our experience balloon angioplasty and Dacron patch were the safest method with acceptable rate of restoration in blood pressure during in-hospital follow-up period.

Key words: Coarctation, aorta, intervention, surgery, outcome, complication

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1. INTRODUCTION

Coarctation of the aorta (CoA) is a congenital or acquired abnormality characterized by narrowing of the proximal part of the aorta, usually distal to the left subclavian artery. This narrowing causes obstruction to blood flow in the aorta (1). Consequently systemic hypertension occurs and blood pressure difference between the upper

and lower extremities goes beyond 20 mmHg (2). CoA is relatively a common condition and accounts for 5-8% of all congenital heart diseases. Its incidence is 0.3-0.4 per 1,000 births(3, 4). The incidence of CoA is higher in some chromosomal disorders such as Turner's syndrome. In congenital form of CoA, there is medial thickening and intimal hyperplasia. It is also more common in males than in females (5). Most cases

of CoA are diagnosed in childhood and less than one-fourth are diagnosed after 10 years of age (1). If left untreated, 90% of patients die before 50 years of age. Half of these deaths occur in the first 10 years of life, usually due to heart failure. About 25% of deaths occur in the age range of 14-20 years and usually due to endocarditis, intracerebral hemorrhage, and valvular heart diseases. Studies about natural history of CoA reveal that mean age of death in patients with uncorrected CoA is 31 years (6). The most important clinical manifestation of CoA in older children and adolescents is difference in systolic blood pressure between the upper and lower limbs. Surgical treatment either in the form of surgery or interventional procedures are the standard of treatment in CoA. The goal of surgery is to bypass the narrowed segment of the aorta. Several techniques have been reported in the literature to correct CoA including left subclavian aortoplasty (7), resection and end-to-end anastomosis (8), angioplasty with Dacron patch (9), stenting (10), and balloon angioplasty (11). Several factors affecting the surgeon's decision in selecting a technique such as surgeon's preference, age of the patient, type of coarctation, etc. Here we intended to report our experience in a 10-year period regarding treatment of CoA and short-term (in-hospital) outcomes and complications.

2. MATERIALS AND METHODS

In this retrospective study, the medical records of all patients with the diagnosis of CoA who underwent surgical or interventional procedures at Imam Ali Hospital in Kermanshah, Iran from March 2002 to March 2012 were reviewed. The age range considered here was from 5 to 25 years. The data gathered included age, gender, weight, blood pressure, symptoms of CoA, echocardiography findings, concomitant congenital cardiac defects, the type of CoA, peak systolic gradient before and after surgery, the type of surgical procedure performed, duration of hospitalization, treatment outcome (need for repeated surgery, mortality, etc), complications of the surgery, death, and its cause. The data were expressed using descriptive indices such as frequency, percentage, mean and its standard deviation (SD). To compare categorical variables, the chi-squared test was used and for comparison of continuous variables the student t-test was applied. All analyses were accomplished using the SPSS Software for Windows (ver. 18.0). The significance level was set at 0.05.

3. RESULTS AND DISCUSSION

There were 64 patients (48 males and 16 females) aged 5-25 years who underwent treatment at our medical center. There were 30 cases (46.9%) in age group of 5-10 years, 13 cases (20.3%) in 11-15 years, 11 cases (17.2%) in 16-20 years, and 10 cases (15.6%) in 21-25 years. There were 35 patients (54.7%) with simple CoA and 29 patients (45.3%) with complex CoA. Sixty patients (93.8%) had primary CoA and 4 patients (6.3%) had secondary CoA. Regarding anatomy, 57 cases (90.5%) had discrete CoA and 6 cases (9.5%) had segmental CoA. Twenty-three patients (35.9%) were taking captopril and one patient (1.6%) was taking antibiotic. For 26 patients, surgical procedures were done including 4 patients with subclavian artery flap (8.7%), end-to-end anastomosis (27 cases, 58.7%), and Dacron patch (15 cases, 32.6%). For 18 patients (12 males and 6 females), interventional procedures were performed including stenting (14 cases, 21.8%) and balloon angioplasty (4 cases, 6.2%). Three patients (4.7%) had undergone end-to-end anastomosis previously and one patient (1.6%) had undergone balloon angioplasty. Mean (\pm SD) systolic blood pressure values before and after treatment were 140.9 (\pm 10.3) and 119.8 (\pm 10.2) mmHg, respectively ($P < 0.001$). Mean (\pm SD) diastolic blood pressure before and after treatment were 85.9 (\pm 6.4) and 79.4 (\pm 6.9) mmHg, respectively ($P < 0.001$). Mean (\pm SD) peak systolic gradient decreased from 44.9 (\pm 8.7) mmHg to 24.08 (\pm 4.6) mmHg after surgery ($P = 0.013$).

3.1. Gender

No complication occurred in 32 males (66.7% of males) and 7 females (43.8% of females). Sixteen males (33.3% of males) experienced complications including hypertension (29.2%), persistent CoA (2.1%), and wound infection and fever (2.1%). 50% of females had hypertension and 6.3% had CoA recurrence after surgery.

3.2. Age group

Table 1 shows complications of surgery according to age group of the studied sample. Age groups of 16-20 years, 21-25 years, 11-15 years, and 5-10 years had in order the safest profile of post-operative complications.

Table 1. Complications/outcome reported after coarctation of the aorta surgical treatment based on age groups of the studied sample

Age group	No complication	Hypertension	Persistent coarctation	Surgical wound infection and fever	Total
5-10 years	16 (53.3%)	12 (40%)	2 (6.7%)	0	30
11-15 years	8 (61.5%)	4 (30.8%)	0	1 (7.7%)	13
16-20 years	8 (72.7%)	3 (27.3%)	0	0	11
21-25 years	7 (70%)	3 (30%)	0	0	10
Total	39 (60.9%)	22 (34.3%)	2 (3.2%)	1 (1.6%)	64 (100%)

Frequency distribution of complications in interventional procedures group based on age group was 5-10 years (11 cases, 7 had hypertension), 11-15 years (4 cases, two had hypertension), 16-20 years (one patient), and 21-25 years (2 patients) with no complications. No significant relationship was found between age group and in-hospital complications in interventional procedures group (P= 0.28). Frequency distribution of complications in surgical procedures group based on age group was 0-5 years (5 cases, one had hypertension), 6-10 years (14 cases, 4 had hypertension and two had persistent coarctation), 11-15 years (9 cases, two had hypertension and one experienced surgical wound infection), 16-20 years (10 cases, three had hypertension), and 21-25 years (8 patients, three had hypertension). No significant relationship was found between age group and in-hospital complications in interventional procedures group (P= 0.65).

3.3. Simple vs. Complex CoA

Of 29 patients with complex CoA, 15 patients (51.7%) had patent ductus arteriosus, 8 patients (27.5%) had aortic stenosis and dilation, three patients (10.34%) had bicuspid aortic valve, one patient (3.4%) had aneurysm of the aorta, one patient (3.4%) has atrial septal defect, and one patient (3.4%) had aortic insufficiency. Of 15 patients with patent ductus arteriosus, 7 cases (46.7%) had no post-operative complication, 7 cases (46.7%) had hypertension, and one case (6.7%) experienced coarctation recurrence after surgery. Of 8 patients with aortic stenosis and dilation, 6 cases (75%) had no complication, but two patients (25%) had hypertension in post-operative follow-up. Coarctation recurrence occurred in the patient with aneu-

rysmal aorta. Those with bicuspid aortic valve, atrial septal defect, and aortic insufficiency experienced no post-operative complication. There was significant relationship between complex CoA and complications occurred during hospitalization (P= 0.01). Neither in interventional procedures group nor in surgery group significant relationship was detected regarding complex CoA and in-hospital complications (data not shown).

3.4. Primary vs. secondary CoA

Of 60 patients (93.8%) with primary CoA, 35 cases (58.3%) had no complications during hospitalization, but 22 cases (36.7%) had hypertension, 1 patient (1.7%) had surgical wound infection and fever, and 2 patients (3.3%) had persistent CoA. Of four patients with secondary CoA, none of them had post-operative complications. No significant relationship was detected regarding in-hospital complications and the type of CoA (primary vs. secondary) (P= 0.43). In interventional procedures group, 4 patients had secondary CoA who experienced no complications, but of 14 cases with primary CoA, 9 cases (64.3%) had hypertension after procedures (P= 0.04). In surgery group, all patients (46 cases, 100%) had primary CoA and complications occurred in 16 cases (13 patients had hypertension, one case had surgical wound infection, and 2 cases had persistent coarctation).

3.5. Type of surgical treatment

Table 2 presents in-hospital complications based on the surgical treatment done for patients.

Table 2. In-hospital outcome/complications based on the surgical treatments done for patients with CoA.

Group	No complication	HTN	Persistent coarctation	Surgical wound infection and fever	Total
Subclavian artery flap	2 (50%)	2 (50%)	0	0	4
End-to-end anastomosis	17 (63%)	8 (29.6%)	1 (3.7%)	1 (3.7%)	27
Dacron patch	11 (73.3%)	3 (20%)	1 (3.7%)	0	15
Stenting	6 (42.9%)	8 (57.1%)	0	0	14
Balloon angioplasty	3 (75%)	1 (25%)	0	0	4
Total	39 (60.9%)	22 (34.3%)	2 (3.2%)	1 (1.6%)	64 (100%)

Balloon angioplasty followed by Dacron patch had the safest profile of in-hospital complications. No significant relationship was found between in-hospital complications and the type of surgery method (operative and interventional) performed (P= 0.81).

3.6. Discrete vs. segmental CoA

Of 57 patients with discrete CoA, 34 cases (59.6%) had no complications. Complications occurred were hypertension (21 cases, 36.8%), persistent coarctation (1 case, 1.8%), and surgical wound infection (1 case, 1.8%). Of 6 cases with segmental CoA, 4 cases (66.7%) had no complications, but 1 patient (16.7%) had hypertension and another patient (16.7%) had persistent coarctation. No significant relationship was found between in-hospital complications and CoA anatomy (P= 0.205).

3.7. Blood pressure

Table 3 shows in-hospital post-operative complications based on pre-operative systolic and diastolic blood pressure as well as peak systolic gradient.

Table 3. Relationship between pre-operative systolic and diastolic blood pressure as well as peak systolic gradient and in-hospital complications/outcome

Group	mmHg	No complication	HTN	Persistent coarctation	Surgical wound infection and fever	P value
SBP	100-120 (N= 1)	0	1 (100%)	0	0	0.48
	121-140 (N= 35)	19 (54.3%)	13 (37.3%)	2 (5.7%)	1 (2.9%)	
	141-160 (N= 28)	20 (71.4%)	8 (28.6%)	0	0	
DBP	70-90 (N= 59)	37 (62.7%)	20 (33.9%)	1 (1.7%)	1 (1.7%)	0.14
	> 90 (N= 5)	2 (40%)	2 (40%)	1 (20%)	0	
PSG	21-40 (N= 23)	16 (69.6%)	7 (30.4%)	0	0	0.84
	41-60 (N= 38)	21 (55.3%)	14 (36.8%)	2 (5.3%)	1 (2.6%)	
	>61 (N= 3)	2 (66.7%)	1 (33.3%)	0	0	

SBP= systolic blood pressure; DBP= diastolic blood pressure; PSG= peak systolic gradient

No significant relationship was found between blood pressure and peak systolic gradient with in-hospital complications. Pre-

operative systolic blood pressure had no significant relationship with in-hospital complications either in interventional group or surgical group (data not shown). In interventional procedures group, no significant relationship was found between pre-operative peak systolic gradient and complications (data not shown).

3.8. Hospitalization duration

Table 4 presents in-hospital complication reported based on hospitalization duration after surgical treatments.

Table 4. In-hospital complications/outcome based on hospitalization duration

Group	No complication	HTN	Persistent coarctation	Surgical wound infection and fever
1-5 days (N= 18)	9 (50%)	9 (50%)	0	0
6-10 days (N= 42)	27 (64.3%)	13 (31%)	2 (4.8%)	0
≥ 11 days (N= 4)	3 (75%)	0	0	1 (25%)

In interventional procedures group, duration of hospitalization was 1-5 days for all patients. There was a significant relationship between hospitalization duration and complications (P= 0.004). CoA is a congenital or acquired defect which based on clinical presentation, severity, and experience of surgeons require timely surgery treatment to improve survival of the patients. One of the effective measures in assessing the outcome of surgery is blood pressure decrease after surgery. In our study, systolic blood pressure, diastolic blood pressure as well as peak systolic gradient all decreased significantly after treatment. This was seen in all treatments applied here either surgery or interventional procedures and in all age groups. This hemodynamic finding is a good indicator of effectiveness of treatments performed. This is consistent with former reports. Forbes et al (12). In their study also reported decrease in post-operative systolic blood pressure as well as systolic gradient. Some studies have defined a decreased of 20 mmHg in systolic gradient across coarctation segment as a success of treatment (12). The severity of systolic or diastolic hypertension before surgery did not have relationship with post-operative outcome or complication. This was also seen in terms of pre-operative peak systolic gradient. This is in contrast with former studies which reported that patients with a systolic arterial pressure of ≥ 165 mm Hg before dilatation had a higher risk of persisting

hypertension after the procedure (HR 2.7, 95% CI 1.2 to 6.7) (11). Likewise, age group of the patients did not have significant relationship with in-hospital complications, though in children of 5-10 years old, we observed higher rate of complications compared to other age groups. The most common complication in all age groups was systemic hypertension. Residual hypertension has been reported in the literature from 27%-68% (11). This was 34.3% in our study and in all age groups as well as in all treatments used, systemic hypertension was the most common complication. No case of aortic wall injury or dissection occurred in the studied patients. These complications seem to be rare, but have been reported earlier which necessitates repeated interventions (13, 14). In general, none of the studied patients required an emergency repeated surgical intervention during hospitalization. Among procedures performed, balloon angioplasty was the safest and of 4 patients who received this treatment, only one patient had systemic hypertension after the intervention. However, of 4 patients who received subclavian artery flap, 2 patients (50%) had persistent systemic hypertension. Dacron patch also showed a safe profile with satisfactory outcomes nearly similar to balloon angioplasty. Of 15 patients treated with Dacron patch, 11 patients had good outcome, and three patients had systemic hypertension. One patient also had persistent coarctation. However, in balloon angioplasty no case of persistent coarctation occurred. In our results, stenting did not associate with a good result as reported by balloon angioplasty or Dacron patch. More than half of patients who received stenting had persistent hypertension. This is in contrast with Forbes et al. study (12). In their large-scale multi-institutional study on 350 patients with CoA, they compared stenting, balloon angioplasty, and surgery. All 3 methods associated with satisfactory improvement in short-term follow-up in decreasing systolic blood pressure as well as peak systolic gradient and even stenting method was superior to balloon angioplasty in controlling high blood pressure. Surgery and stenting were superior to balloon angioplasty at short-term follow-up in achieving lower upper-lower extremity gradient. According to their results, patients who were treated with stenting had shorter hospitalization than surgical patients and fewer complications than surgical and balloon angioplasty patients. Neither anatomic type of CoA (discrete or segmental) or simplex vs. complex CoA had relationship with in-hospital complications. However, regarding primary vs. secondary CoA, in interventional procedures

group, those with primary CoA had significantly higher complications than secondary type. As expected, with longer hospitalization duration, complications were more common. Several factors affect persistent hypertension or complications during in-hospital stage, which should be considered in interpretation of the data obtained here. These include severity of coarctation, age of patients, concomitant congenital defects. For example, some experts suggest that stenting is not a good alternative to surgery in children because it fails to adapt to vessel growth in this age group. They recommend balloon angioplasty in this group (11). As demonstrated, balloon angioplasty here was the safest method and most cases of hypertension and surgical wound infection were seen respectively in stenting and end-to-end anastomosis methods.

4. CONCLUSION

In conclusion, we suggest considering all aspects of patients with CoA to choose the best surgical treatment. Based on our experience balloon angioplasty and Dacron patch were the safest method with acceptable rate of restoration in blood pressure during in-hospital follow-up period.

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AUTHORS CONTRIBUTION

This work was carried out in collaboration between all authors.

CONFLICT OF INTEREST

Authors have declared that no conflict interests exist.

REFERENCES

1. Doshi AR, Rao PS. Coarctation of Aorta-Management Options and Decision Making. *Pediatrics & Therapeutics*. 2012;5(6):1-10.
2. Hamdan MA, Maheshwari S, Fahey JT, WE H. Endovascular stents for coarctation of the aorta: initial results and intermediate-term follow-up. *J Am Coll Cardiol* 2001;38(5):1518-23.

3. Golden AB, WE H. Coarctation of the aorta: stenting in children and adults. *Catheter Cardiovasc Interv.* 2007;69(2):289-99.
4. E R. Coarctation of the aorta from fetus to adult: curable condition or lifelong disease process? *Heart.* 2005;91(11):1495-502.
5. Tennstedt C, Chaoui R, Korner H, M. D. Spectrum of congenital heart defects and extracardiac malformations associated with chromosomal abnormalities: results of a seven year necropsy study. *Heart.* 1999;82(1):34-9.
6. Jenkins NP, C. W. Coarctation of the aorta: natural history and outcome after surgical treatment. *QJM.* 1999;92(7):365-71.
7. Shenberger JS, prophet SA, Waldhausen JA, dawidson Wr Jr, LI S. Left subclavian flap aortoplasty for coarctation of the aorta: effects on forearm vascular function and growth. *J Am Coll Cardiol.* 1989;14(4):953-59.
8. Kaushal S, Backer CL, Patel JN, Patel SK, Walker BL, Weigel TJ, et al. Coarctation of the aorta: midterm outcomes of resection with extended end-to-end anastomosis. *Ann Thorac Surg* 2009;88(6):1932-8.
9. Swan L, Wilson N, Houston AB, Doig W, Pollock JC, WS. H. The long-term management of the patient with an aortic coarctation repair. *Eur Heart J.* 1998;19(1):382-86.
10. MR E. Balloon expandable stents for coarctation of the aorta: review of current status and technical considerations. *Images Paediatr Cardiol.* 2003;5(2):25-41.
11. Zabal C, Attie F, Rosas M, Buendia-Hernandez A, JA G-M. The adult patient with native coarctation of the aorta: balloon angioplasty or primary stenting? *Heart.* 2003;89(1):77-83.
12. Forbes TJ, Kim DW, Du W, Turner DR, Holzer R, Amin Z, et al. Comparison of surgical, stent, and balloon angioplasty treatment of native coarctation of the aorta: an observational study by the CCISC (Congenital Cardiovascular Interventional Study Consortium). *J Am Coll Cardiol.* 2011;33(4):2664-74.
13. Varma C, Benson LN, Butany J, PR. M. Aortic dissection after stent dilatation for coarctation of the aorta: a case report and literature review. *Catheter Cardiovasc Interv.* 2003;59(4):528-35.
14. Tan JL MM. Emergency stent graft deployment for acute aortic rupture following primary stenting for aortic coarctation. *Catheter Cardiovasc Interv.* 2005;65(2):306-9.