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Aortic Coarctation in Neonates and Infants: Balloon Angioplasty or Surgical treatment?

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Abstract. Coarctation of the aorta (CoA) is a discrete stenosis of the proximal thoracic aorta. The common clinical pattern is congestive heart failure in infancy. Treatment methods include balloon angioplasty (BA) and surgical repair in this age group. Percutaneous balloon angioplasty is a less invasive method for the repair of discrete coarctation but remains controversial as a primary treatment strategy for a native coarctation. This study aimed at comparing the efficacy and outcome of balloon angioplasty and surgical repair in infants with aortic coarctation younger than one year old.

Methods. Between January 2007 and December 2018, 155 patients with native aortic coarctation were treated in National Amosov Institute of Cardiovascular Surgery. This retrospective study evaluated the results of the two methods in patients younger than one year old with the diagnosis of aortic coarctation. Group 1 included 78 patients following balloon dilatation for discrete coarctation. Group 2 included 77 patients following surgical resection with end-to-end anastomosis. Patients with complex cardiac anomalies were not included in this study.

Results. Immediate results revealed no significant difference in the efficacy of the two methods (p=0.17), with the rate of recurrent coarctation significantly lower in the surgery group [3 (3.8%) vs. 32 (41%), p<0.05]. The mean hospital stay was 6.7±3.2 days in the balloon angioplasty group and 21.4±8.1 days in the surgery group, which constitutes a significant statistical difference (p<0.05). Aneurysm formation was not reported.

Conclusion. Our own experience testifies that both surgical correction and balloon angioplasty of aortic coarctation in infants are effective and give a good immediate result. Balloon angioplasty may be an acceptable alternative to surgical treatment in infants with critical aortic coarctation, although it is accompanied with an increased level of recoarctation. Recoarctation after balloon dilatation is manifested in the first 3-4 months of postoperative follow-up and requires repeated correction by a surgical or endovascular method.

Keywords: *aortic coarctation, balloon angioplasty, infants.*

Aortic coarctation in new-borns and nursing infants is abnormal development of the aorta in the perinatal period in the form of a limited, local intraluminal narrowing of the aorta in the projection of its isthmus in the form of an hourglass or aperture with a small opening. Aortic coarctation is one of the most common congenital heart defects, occurring in 4-6% of patients with congenital heart disease, with male patients more likely to suffer than female patients [1]. This anomaly was described by Johannes Morgan in 1761 [2]. The first surgical correction of the CoA was performed in 1944 by S. Crawford and D. Nilin, and for 40 years the surgical method have practically no alternative. In 1983, S. Lababidi performed the first transcatheter aortic coarctation angioplasty [1, 2, 6]. Despite years of experience in the treatment of this defect, the optimal tactics for treating CoA in infants remain controversial.

Materials and methods

In the period from 2007 to 2018, 155 consecutive patients under 1 year of age with aortic coarctation were treated at the State Institution “National Amosov Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine”. The mean age of the patients was 3.2 ± 1.4 months (from 0 to 12 months), the average weight was 5.3 ± 1.7 kg (from 2 to 10 kg). Patients were divided into two groups according to the type of treatment. The first group consisted of 78 patients who underwent balloon angioplasty. The second group consisted of 77 patients who underwent surgical correction. All patients hospitalized at the State Institution “National Amosov Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine” underwent a complete examination, which included: history, general clinical methods including laboratory examinations (complete blood count and blood biochemistry, haemostatic system analysis, urine, blood gas composition), routine and chest lead electrocardiography, chest radiography, complete echocardiographic examination in one- and two-dimensional mode using colour Doppler. All patients underwent neurosonography before surgery to exclude pathological changes in the brain. CoA was diagnosed on the basis of a combination of clinical features (blood pressure gradient between the upper and lower extremities > 20 mmHg, absent or weakened femoral artery pulse) and typical signs of CoA during Doppler echocardiographic examination. If the examination detected discrete coarctation, and the patient showed signs of severe heart failure, then it was recommended to conduct angioplasty as a palliative procedure for the patient to survive the critical period and get stabilized. Angioplasty was started using balloons with a diameter equal to the diameter of the aortic isthmus or segment B of the aortic arch.

Comparative characteristics of patients, including age, gender, weight, blood pressure, are given in Table 1.

Table 1. Characteristics of patients

Parameter	Group 1 Balloon angioplasty (n=78)	Group 2 Surgery (n=77)	P
F/M	26/52	27/50	0.3
Age (mo)	2.4±1.7	4.3±2.1	0.09
Weight (kg)	4.2±1.4	6.5±2.3	0.2
Pressure gradient (mmHg)	64.3±17.3	59.2±11.3	0.56
Ejection fraction (%)	46.4±9.3	64.2±8.3	<0.05

Balloon angioplasty was performed according to the standard procedure. All procedures were performed by combining local anaesthesia with lidocaine and intravenous administration of ketamine (1 mg/kg/dose) for sedation. All patients received antibiotic prophylaxis. To prevent thromboembolic complications, heparin (100 U/kg) was administered. The technique involved implanting a stent with access through a puncture of the femoral artery through which a 4F-introducer was positioned. A 5-7 mm balloon was introduced in Ao through it. The catheter was inserted into the descending aorta and blood pressure was measured distal to its narrowing. Subsequently, the catheter was passed through the CoA into the ascending Ao and aortography was performed in the LAD 30° projection and lateral projection. A balloon with a diameter equal to segment B of the aortic arch was selected. The dilation was performed under a pressure of 2 atm. A reduction in the systolic pressure gradient at the CoA site to a level <20 mmHg was considered a success.

In surgical treatment, all patients underwent lateral thoracotomy in the 3rd intercostal space on the left. The ascending Ao, left subclavian and carotid arteries were isolated and mobilized. The arterial duct was sutured and crossed. When dissecting the stenotic Ao segment, the peritoneal tissues were carefully separated. The stenotic segment of Ao was excised and a simple end-to-end anastomosis connected the resected edges in all children who did not have hypoplasia of the proximal or distal aortic arch. In the presence of a hypoplastic aortic arch, a resection was performed with the placement of an extended end-to-end anastomosis to the aortic arch.

Results and discussion

In both study groups, there were no deaths. Comparative results of the study are given in table. 2. The mean pressure gradient in group 1 decreased from 64.3 ± 17.3 to 18.5 ± 6.4 mm Hg after surgery ($p < 0.05$). In group 2, the mean pressure gradient decreased from 59.2 ± 11.3 to 14.3 ± 4.4 mm Hg ($p < 0.05$). The average length of hospital stay was 6.7 ± 3.2 days in the angioplasty group and 21.4 ± 8.1 days in the surgical group, which is a significant statistical difference ($p < 0.05$).

Table 2. Comparison of treatment outcomes in the study groups

Parameters	Group 1 Balloon angioplasty (n=78)	Group 2 Surgery (n=77)	P
Systolic pressure gradient (SPG) (mmHg)	64.3±17.3	59.2±11.3	0.08
SPG immediately after the procedure	18.5±6.4	14.3±4.4	0.17
SPG 6 mo after	41.4±11.3	15.7±6.4	<0.05
SPG 12 mo after	47.3±16.4	17.5±8.7	<0.05
Ejection fraction upon disacharge (%)	62±4.3	67±2.9	0.26
Stay in the hospital (days)	6.7±3.2	21.4±8.1	<0.05
Recurrent interventions due to recoarctation (1st year)	32 (41%)	3 (3.8%)	<0.05
Hospital mortality	0	0	–

All complications of the hospital phase in the comparison groups are given in Table 3.

Table 3. Complications of the hospital phase

Complications	Group 1 Balloon angioplasty (n=78)	Group 2 Surgery (n=77)	P
Intima rupture	2	0	–
Chylothorax	0	2	–
Wound infection	0	3	–
Aneurysm formation in the intervention area	0	0	–
Partial lung atelectasis	3	7	–
Hemotransfusions	0	4	–
Total	**5**	**16**	**<0.05**

Arteriosection was performed to access the femoral artery in one patient, after an unsuccessful percutaneous attempt. Upon further observation, both lower extremities developed equally. Two patients had chylothorax after surgical aortoplasty, leading to prolonged drainage of the pleural cavity. All patients were

treated conservatively. In the balloon angioplasty group, no patient required transfusion of blood components. In the surgical group, 4 patients had anaemia that required blood transfusion after surgery. In 7 patients of the surgical group, partial lung atelectasis was detected, in 3 – wound infection. In general, 20.7% of patients in the surgical group had at least one complication after surgery compared with 6.4% of patients in the balloon angioplasty group ($p < 0.05$).

The average long-term follow-up period was 19 months (8-48 months). Echocardiography was used to measure the changes in the pressure gradient in the correction area every 6-12 months or in the presence of weakened femoral artery pulse during follow-up. Recoarctation was determined when the pressure gradient exceeded 25 mm Hg when measured by transthoracic echocardiography and > 20 mm Hg during further catheterization of the heart.

In the first group, recoarctation was identified in 32 (41%) patients. All recoarctations were localized at the site of balloon intervention without the spread of stenosis to the isthmus. In all of these patients, recoarctation manifested itself within the first 3-4 months after the initial intervention. All such patients underwent radical surgical correction. In the second group, recoarctation was detected in 3 (3.8%) patients and localized in the anastomotic zone. They had no hypoplasia of the aortic isthmus and arch. Patients successfully underwent repeated balloon angioplasty.

Discussion

Surgical correction provides good results in the treatment of patients with coarctation of the aorta since S. Crawford described the first successful correction of this defect in 1946 [1, 2]. Balloon angioplasty was proposed as an alternative to classic surgery for primary treatment of CoA in 1982 [1, 2]. Despite the disappointing results of balloon dilation in the initial reports, further experience is more optimistic. However, the number of studies comparing balloon angioplasty with surgical treatment is limited. Significant reduction in systolic gradient can be achieved in both surgery and angioplasty [2, 4, 5]. The rate of hospital mortality was similar, but after balloon angioplasty, a higher incidence of recoarctation in infants was found compared to surgical treatment [3-5].

It is known that recoarctation occurs in 10-30% in the remote period after surgical treatment [2-6]. At the same time, restenosis after balloon angioplasty was observed in 11-60% [1, 2, 4, 5]. Such a discrepancy may depend on specific aspects of surgical angioplastic technique. Mechanisms of recoarctation may be due to inadequate growth of the anastomosis, active fibrosis and narrowing in the anastomosis area, thrombosis along the suture line and residual abnormal ductal tissue.

In our study, balloon angioplasty is quite successful, with good immediate results, a low incidence of complications, and a short stay in hospital. The drawback is the high level of recoarctation when using this method. These results allow us to argue that balloon angioplasty can be effectively used in symptomatic patients with

critical coarctation. Similar experience has also been described by other researchers [4–6].

Conclusion

Our own experience testifies that both surgical correction and balloon angioplasty of aortic coarctation in infants are effective and give a good immediate result. Balloon angioplasty may be an acceptable alternative to surgical treatment in infants with critical aortic coarctation, although it is accompanied with an increased level of recoarctation. Recoarctation after balloon dilatation is manifested in the first 3-4 months of postoperative follow-up and requires repeated correction by a surgical or endovascular method.

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