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Rate of reinterventions and restenosis after aortic arch repair in Infants

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Abstract

Restenosis after aortic arch repair is well known complication in infants. The purpose of this study is to identify the reintervention rate in infants with aortic arch repair. Cohort retrospective study of 200 infants with aortic arch hypoplasia who did aortic arch reconstruction between 2010 and 2021. The procedures for primary repair included extended end-to-end anastomosis (n = 175) and autologous pericardial patch repair (n = 25). The overall mortality in the entire study group was 4.7 %. Follow-up period ranged from 5 month to 10 years (mean 2.2 ± 2.3 years). Restenosis at the site of aortic arch repair was identified in 60 (14.3 %) patients. Furthermore 15 patients underwent surgical reconstruction of the aortic arch, 30 patients underwent balloon angioplasty, and in 4 patients both methods were used. In conclusions surgical treatment of aortic arch hypoplasia in infants is effective and shows good immediate and long-term results.

Keywords: Restenosis; Aortic arch; Infants; Reintervention rate

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Introduction

Aortic coarctation accounts for 5 % to 8 % of congenital heart diseases in children and is frequently associated with aortic arch hypoplasia [1]. Recurrent aortic arch obstruction remains an important complication after aortic arch reconstruction in infants and occurs in a number of patients in surgical series [2]. In literature there are many studies on risk factors of reobstruction after aortic arch repair in infants. Despite many different techniques for arch reconstruction, some authors announced that the restenosis rate is directly associated with arch anatomy and the type of repair [3].

It is often thought that age at time of reconstruction, low weight in neonates, and preoperative care are associated with higher risk of recurrent obstruction [4]. The recurrence rate of arch obstruction and recurrent interventions varies in different series and ranges from 2 % to 40 % [5]. There is currently no consensus on the optimal methods for recurrent aortic obstruction. Strategies to treat recurrent aortic arch obstruction have evolved with time [6]. Over the last 2 decades, balloon angioplasty has been more widely used, but several publications still

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recommend surgery as a more effective treatment for re stenosis at the site of previous aortic arch repair [7].

The aim of our study is to determine the reintervention rate in infants undergoing aortic arch repair and to analyze risk factors and evaluate the results of reinterventions.

Patients and methods

The study included 200 infants who underwent aortic arch repair due to aortic coarctation with aortic arch hypoplasia at the Russian Medical Center, Russia from 2010 to 2021. The study included only patients with two ventricle physiology and subsequent two-ventricle repair. Exclusion criteria: infants with single-ventricle physiology. Aortic coarctation with aortic arch hypoplasia occurred as an isolated defect in 159 (35.7 %) patients and was associated with other cardiac malformations in 286 (64.3 %) patients. There were 284 (63.8 %) males and 161 (36.2 %) females. The mean age of the patients at first operation was 2.3 ± 0.8 months, mean weight was 4.8 ± 1.9 kg. Reinterventions on the aortic arch were performed in 47 (10.5 %) patients who formed the main group of the study. Primary aims included an analysis of restenosis rates and catheterbased or surgical reinterventions for aortic arch obstruction. Characteristics of the patients at the time of reintervention are listed in Table 1. As we can see, the most common surgical technique used at primary aortic arch repair was extended end-to-end anastomosis through a lateral thoracotomy. All the patients underwent routine transthoracic echocardiography.

Anatomical description of the aortic arch was analyzed from echocardiographic data. The diagnosis of aortic arch hypoplasia was established if the deviation of the isthmus distal and proximal aortic arch Z-score was less than or equal to -2. Aortic aneurysm formation was determined if the diameter of the aneurysm was 1.5 times greater than that of the descending aorta at the level of the diaphragm. Reinterventions after primary aortic arch repair included 27 (6.1 %) catheter-based reinterventions, 12 (2.7 %) surgeries, and in 8 patients (1.8 %) both techniques were used (Fig. 1). The most common indication for reintervention was recurrent aortic obstruction at the site of previous arch repair. However, 1 patient had restenosis at the proximal arch and aortic aneurysm at the distal arch after patch aortoplasty. Indications for reintervention after primary aortic arch repair were upper extremity/lower extremity resting.

Surgical technique. Several different surgical techniques for recurrent aortic arch obstruction were used. The technique was chosen by the surgeon individually for each patient. Lateral thoracotomy was used for relief of aortic obstruction in 11 patients. Thoracotomy was chosen because the narrow segment was distal enough to be safely addressed by thoracotomy. Surgical approach did not differ significantly from a primary aortic arch repair. A posterolateral thoracotomy was performed in the third intercostal space. Intrathoracic adhesions were divided paying much attention to the mobilization of vagus and recurrent laryngeal nerves. The aortic arch, left subclavian artery and descending thoracic aorta were dissected from their surrounding adhesions. The vascular clamp was placed directly near the brachiocephalic trunk in the area

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of proximal aortic arch, partially clamping the ascending aorta. At the same time, invasive pressure on the right radial artery was controlled, which is an indicator of adequate blood flow to the right. common carotid artery. Distally, the clamp was placed on the descending thoracic aorta below the previous repair site. The narrowing segment was excised, longitudinal incision was made in the posterior wall of the descending aorta and then aortic arch repair was performed.

Table 1.

Patient characteristics at the time of reintervention.

Characteristics	Reintervention group, n = 47
Age, month	5.8 ± 3.0
Weight, kg	5.9 ± 2.7
Body surface area, m2	0.24 ± 0.04
Surgical techniques	
Extended end-to-end anastomosis	38(80.9 %)
End-to-side anastomosis	8(17 %)
Autologous pericardial patch aortoplasty	1(2.1 %)

Statistical methods

Data are presented as mean ± standard error (SE). Statistical analysis was performed using StatView software (Abacus Concepts, Calabasas, CA, USA). Analysis of variance (ANOVA) with Fisher post-hoc test was used to analyze differences between experimental groups, and differences were confirmed using the Mann-Whitney *U*-test. Statistical significance was defined as $P \leq 0.05$.

Results

The hospital mortality after primary aortic arch repair in infants was 2.7 % (n = 12), mortality in the long term was 0.7 % (n = 3). Analysis of the hospital mortality showed that only one patient died with isolated aortic arch hypoplasia, all others had associated congenital heart disease. It should also be noted that only in one patient the cause of death was ineffective aortic arch repair, resulting in the development of heart failure. In other patients, the reasons were related to associated cardiac defects repair. Follow-up period ranged from 1 month to 9.4 years (mean 2.8 ± 2.5 years). Restenosis at the site of aortic arch repair was identified in 47 (10.5 %) patients. Of these, 12 patients underwent surgical reconstruction of the aortic arch, 27 patients underwent balloon angioplasty, and in 8 patients both methods were used. A total of 58 reinterventions were required for restenosis.

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Median interval from primary arch repair to reintervention for recurrent aortic obstruction was 8.4 ± 1.2 months. Of the 47 patients who underwent reintervention on the aortic arch, 17 (36.1 %) patients weighed less than 2500 g. Hospital mortality after surgical repair of recurrent aortic arch obstruction was 2.1 % (n = 1).

Mortality was not associated with the technique of reintervention on the aortic arch. The cause of death was acute heart and respiratory failure associated with the correction of other congenital heart disease. There were no late deaths. The main characteristics and outcomes for patients who underwent aortic arch reconstruction are described in Table 3. At the time of reintervention, the median systolic gradient across the obstruction was 50.8 ± 17 mm Hg. grading the risk factors for recurrent aortic obstruction. According to systematic review, risk factors for reobstruction of the aorta can be summarized in the following categories: demographic variables, associated anomalies, clinical and intervention variables, morphometric variables [11]. Low weight at intervention is classically viewed as a potential risk factor for restenosis [12, 13]. This is confirmed by several studies, showing a significant association between low body weight at the time of repair and arch restenosis. Bacha et al. identified that weight less than 1.5 kg at the time of primary arch is an independent predictor of recurrent aortic arch obstruction [14]. However, Sudarshan et al. and Jiang et al. noted that low weight was not a significant factor for choosing surgical strategy [15, 16]. Our study shows that weight less than 2500 g is indeed a risk factor for restenosis after neonatal aortic arch repair. Some studies evaluating the association between restenosis and aortic arch morphometry showed that the hypoplastic aortic arch was a significant risk factor for recurrent aortic arch obstruction [17, 18, 19]. For example, McElhinney et al. measured the size of the aortic arch segments by echocardiography and concluded that the size of the transverse aortic arch is an important risk factor for restenosis after neonatal aortic arch repair [5]. Wu et al. also found that the size of the transverse aortic arch is a risk factor for recurrent aortic arch obstruction [20]. In the present study, we found that the diameter of the proximal aortic arch was associated with reintervention for recurrent aortic arch obstruction. Concerning surgical technique, when possible, the reconstruction should be performed using native tissue. Many authors recommend an extended end-to-end or end-to-side anastomosis as the best method of primary hypoplastic aortic arch repair to avoid restenosis [21, 22, 23, 24]. In our study initial repair technique was not associated with recurrent aortic arch obstruction. As for surgical approach for reintervention, both median sternotomy and lateral thoracotomy were used. Surgical approach was chosen after a full preoperative examination including echocardiography, angiography, and magnetic resonance image scanning, and depended on the location and duration of reobstruction. In our opinion, if the narrowing aortic segment is located proximal to the previous repair site and if the transverse aortic arch remains significantly hypoplastic, the best surgical approach will be median sternotomy. If the recurrent obstruction is distal to the left subclavian artery, we used left thoracotomy. The purpose of any reintervention after the initial reconstruction of the aortic arch is to completely eliminate the obstruction for further

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growth of all segments of the aortic arch, minimizing the risk of re-narrowing. Different methods are used to treat recurrent aortic arch obstruction: endovascular interventions (balloon dilatation, stenting), surgical techniques (extraanatomic bypass with synthetic vascular prostheses, anatomic aortic arch). Regarding the treatment strategy, surgical repair of recurrent aortic arch obstruction is preferred in cases when the area of obstruction involves a longer segment of obstruction [2, 25]. Balloon angioplasty has been increasingly used for local recurrent aortic obstruction and becomes the initial procedure of choice in many centers [9, 26]. Balloon dilatation of aortic arch restenosis demonstrates high efficiency of the procedure. Connective tissue at the site of primary surgical repair minimizes the risk of aneurysm formation after balloon dilatation. In our series, patients with suitable anatomy (locally narrowed segment) should have an initial trial of balloon angioplasty. This method was effective in most patients with aortic arch restenosis.

Limitation of study

Aortic arch augmentation was performed both in infants, as well as in univentricular and biventricular repairs. Our study was not powered for further multivariable analysis, and the numbers were too low to perform a subgroup analysis to draw firm conclusions.
Restenosis could be related to a suboptimal initial surgical result. For the earliest portion of our study cohort, patients were subjected to meticulous care, but there was not a standardized protocol for postoperative surveillance, this being developed later and therefore not applied to the whole study population.

Conclusion

Surgical treatment of aortic arch hypoplasia in infants is effective and shows good immediate and long-term results.

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Competing interests

The authors declare no conflict of interest.

Ethics Statement

This study has been approved by the Ethical Review Committee. Before signing the informed consent form, after the patients and their families fully understand the research process, our team members will organize the patients to sign the informed consent form or withdraw from

the research. All subjects or their guardians will sign informed consent. Authors tend to submit research results to peer-reviewed journals or academic conferences for publication.

Authors' contributions

All authors shared in the conception and design and interpretation of data, drafting of the manuscript and critical revision of the case study for intellectual content and final approval of the version to be published. All authors read and approved the final manuscript.

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