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SURGICAL TREATMENT OF NEWBORNS WITH COARCTATION OF AORTA AND SEVERE DISTAL AORTIC ARCH HYPOPLASIA BY MODIFIED AMATO METHOD

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Abstract

Objective: The purpose of this study is to evaluate the effectiveness of surgical treatment of newborns with coarctation of the aorta and severe hypoplasia of the distal aortic arch in a modified Amato method according to the data of the immediate and mid-term results.

Methods: 33 newborns with coarctation of aorta and severe distal aortic arch hypoplasia were subjected through left posterior thoracotomy using for plasty of arch tissue the left carotid artery and the left subclavian artery and then classic resection coarctation next extended end-to-end anastomosis.. Eight of them had associated difficult concomitant cardiac abnormality of large overload blood and associated of high pulmonary hypertension required pulmonary artery banding before distal aortic arch plasty and extended end-to-end anastomosis. Mean age and weight were 9 (6-21) days and 3,4 (2,5-3,9) kg, respectively. Median preoperative Z-score of distal aortic arch was - 3,26 (-4,56 to -2,12) and istmus -3,66 (-5,16 to -2,76).

Results: Thirty one patients had successfully operated by this approach. The non-ischemic and ischemic aortic cross clamping mean time were 28 min and 25 min accordingly. The immediate postoperative mean Z-score of the distal aortic arch was 0.58, and after the

average mid-term period of 4.7 (1-9) years it was – 0.17 (-0.36 to 0.75), which allows it to be affirmed these indicators as normal.

Conclusions: Tissues the left carotid artery and the left subclavian artery after plasty give growth to distal arch of aorta in the mid-term period more than 93,9% of cases.

Keywords: newborn, hypoplastic distal aortic arch, coarctation aorta, aortic arch reconstruction, midterm result

Introduction

Various methods for surgical treatment of neonates with coarctation aorta (CoA) and distal aortic arch (DAA) hypoplasia between the left carotid artery (LCA) and left subclavian artery (LSA) have been used, but recurrent aortic arch obstruction, recoarctation and arterial hypertension are problems in the long term period [2, 3, 5, 9, 10]. Aortic arch hypoplasia of varying degrees is the common diagnosis among congenial heart diseases (CHD) and occurs in 15-40% of patients with CHD [2, 7, 13]. Four decades ago the J.Amato proposed a method for correcting the severe hypoplasia of the DAA that did not get spread, but create basis for development new technologies for repair CoA and DAA hypoplasia (DAAH) [1, 2, 3]. Search the optimal surgical treatment for newborn with CoA and concomitant cardiac abnormality continues [3, 4, 7, 10]. The combination of CoA with other CHD can dramatically complicate the natural course of the disease and urgent surgery is sometimes necessary [7, 11, 12]. Staged approach for correction of CoA with septal defects of large overload and associated high pulmonary hypertension (HPH) through a left-side thoracotomy as a first step plasty hypoplastic DAA by patch after that extended end-to-end anastomosis (EEEA) and then includes pulmonary artery banding (PAB) [7, 8, 10]. This method provides repair with extremely low risk mortality and can be alternative operations through a median sternotomy with the patient on cardiopulmonary bypass (CPB) including deep hypothermic circulatory arrest (DHCA) and selective cerebral perfusion (SCP) [3, 4, 7]. We have advocated modified Amato method because it efficient with good immediate and midterm result.

Patients and methods

Between 2007 and 2016, 33 consecutive newborns (<30 days) with severe CoA and hypoplastic DAA were subjected to operation at the Department of Cardiovascular Surgery at Odessa Regional Children's Hospital in Ukraine.

There were 24 (72,7%) male and 9 (27,3%) female in group. Mean age and weight of the newborns were 9±1,3 (6-21) days and 3,4±0,2 (2,5-3,9) kg, respectively. Three patients with trisomy 21 underwent operations. 18 (56,25%) newborns received a prostaglandin E1 before operation. 12 (36,3%) patients with cardiogenic shock were performed urgent operations. All of these patients had patent ductus arteriosus (PDA) (Table 2). Prenatally CoA was diagnosed in 9 patients (28%). There were patients performed general clinical examination and transthoracic echocardiography (ECHO). Anatomy of malformation and size of aortic arch segments: ascending aorta, PAA (between the innominate and left carotid artery), DAA, istmus and descending aorta were revealed by transthoracic ECHO. Preoperative ECHO measurements are shown in Table 1.

Table 1. The characteristic of the patients and ECHO measurements aorta before and after modified Amato method

Measurement	Before operation (n=33)		At discharge (n=32)		Midterm (n=32)	
		p		p		p
Body weight (kg)	3,6 (2,5-3,9)	0,235	3,6 (3,1-3,9)	0,235	13,8	0,364
Body surface area (m2)	0,23 (0,2-0,24)	0,259	0,23 (0,2-0,24)	0,259	0,64	0,178
Ascending aorta z-score	-0,56 (-0,96 to 0,87)	0,672	-0,56 (-0,96 to 0,87)	0,672	0,35 (0,65 to 0,04)	0,04
PAA z-score	-0,38 (-0,85 to 0,44)	0,032	-0,38 (-0,85 to 0,44)	0,032	-0,11 (-0,89 to 0,15)	0,032
DAA z-score	-3,26 (-4,56 to -2,12)	0,001	0,58 (-0,44 to 1,55)	0,05	0,17 (-0,36 to 0,75)	0,04
Isthmus z-score	-3,66 (-5,16 to -2,76)	0,782	2,83 (3,02 to 1,43)	0,03	0,28 (-0,15 to 1,26)	0,03
Descending aorta z-score	1,24 (-0,3 to -2,25)	0,073	1,24 (1,69 to 1,11)	0.04	0,01 (-0,44 to 0,65)	0,02

In 5 newborns (15,6%) computed tomography with contrast was performed due to incomplete information by ultrasound examination.

Z-score is the significant criterion in detection of hypoplastic segments arch of the aorta. In patients with DAAH median preoperative Z-score of aortic arch segments were istmus -3,66; DAA - 3,26; PAA -0,38. All patients had with CoA and DAAH. In these cases we had operated modified Amato distal aortic arch plasty as a first stage. The second stage included PDA closure,

resection of the coarctation and EEEA between descending aorta and aortic arch was created. 13 (39,3) patients had CoA, DAAH with septal defects of large overload and associated HPH such as a VSD (multiple), CAVC, SV (Table 2). According to that hemodynamic changes for these patients firstly were performed the pulmonary artery banding, then made modified Amato distal aortic arch plasty and the EEEA. All steps were performed in a single operation sequentially.

Table 2. CoA and DAAH with associated CHD

Associated intracardiac anomalies	Number (%)
PDA	33 (100%)
VSD*	10 (30,3%)
ASD*	11 (33,3%)
BAV*	10 (30,3%)
SV*	5 (15,15%)
CAVC*	2 (6,06%)
AS*	2 (6,06%)

VSD – ventricular septal defect, ASD - atrial septal defect CAVC-complete atrioventricular canal, BAV- bicuspid aortic valve, SV-single ventricle, AS - aortic stenosis

Statistical analysis

In the course of article, standard methods of descriptive statistics used to represent data, depending on their type and distribution, were used. The variation in quantitative indicators was described using the mean and standard deviations in the case of Gaussian distribution. Otherwise, median, quartile, and minimum and maximum values are calculated. For pair comparison of groups whose values were measurement of indicators before and after surgery, the Wilcoxon methods or the tentative t-criterion of Student were used. The comparison of quantitative characteristics in the study groups was performed according to the conjugation tables (krostabulations) with Pearson's $\chi 2$ criterion (including Yates corrections and plausibility), and in the 2×2 format tables, taking into account the statistical significance of Fisher's exact criterion. Statistical analysis of data was performed using the program package IBMSPS Statistics 21.0. The level of statistical significance was considered $p < 0,05$ (taking into account the Bonferon amendment).

Technique of modified Amato operation:

Surgery was performed under general anesthesia with artificial ventilation of the lungs. Arterial pressure monitoring was established by catheterisation in the arteria radialis right upper

extremity and noninvasive pressure of the legs. Cerebral oxygen saturations were monitored during whole operation. Before clamping the aorta heparin 50-100 U per kg was injected i.v.

All operations were performed through a left thoracotomy through fourth intercostal space the aortic arch and neck vessels with distal descending aorta were mobilized. The operation has two stages. The first stage was widening procedure of the aortic arch leading to the incision line (Figure 1) in the drowings.

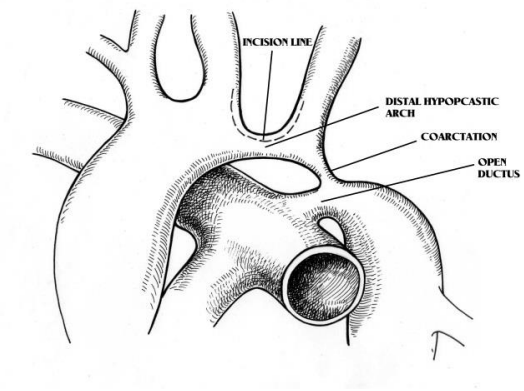

Figure 1

A Cooley vascular clamp was placed across the aortic arch between truncus brachiocephalicus (TB) and the LCA (distance must be ≥6 mm) as important condition this operation. The isthmus of the aorta was closed by snare with tourniquet (Figure 2). During this stage a patent ductus arteriosus helps to perfuse the descendence of aorta and the surgeon has enough time to perform a perfect reconstruction DAAH.

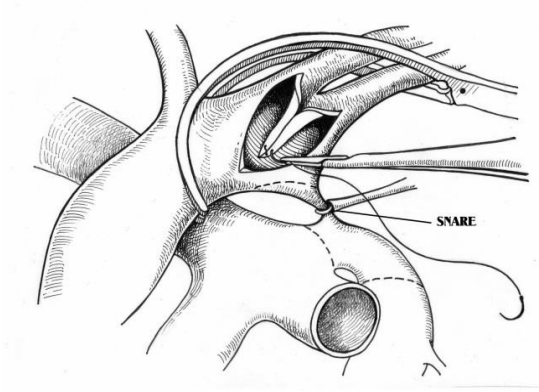

Figure 2

Aorta was opened between the LCA and the LSA. The incision was prolonged 10-12 mm out in both of these branches. We began suture for creating back lip anastomosis by 7/0 polypropylene. The first punctures two needles were inserted on the back wall of the aorta with the knitting behind the vessel. One thread with a continuous suture formed the back lip and was

drawn to the front wall. The front lip was made the same method and both threads tied. Clamp was opened and hemostasis controlled (Figure 3).

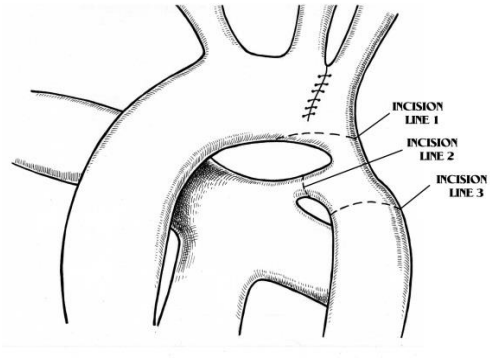

Figure 3

We had saved successfully pulsating blood flow by LCA and LSA in all cases. Normally we waited 15 minutes before we continue so that the upper part of the body is perfused fully for a while and so that the suture line is controlled. The PDA is divided (incision line 2) and pulmonary artery is sutured. There are two incision lines more (Figure 3) where places to removing CoA and all ductal tissue. The second stage of the operation starts by Cooley clamping the new aortic arch and the descending aorta with a straight vascular clamp (Figure 4).

Clamp was reapplied and resection isthmus made. Incision line 1 was made at the buttom of the arch (Figure 3). The established EEEA by 7/0 polypropylene represent in the drawing (Figure 5).

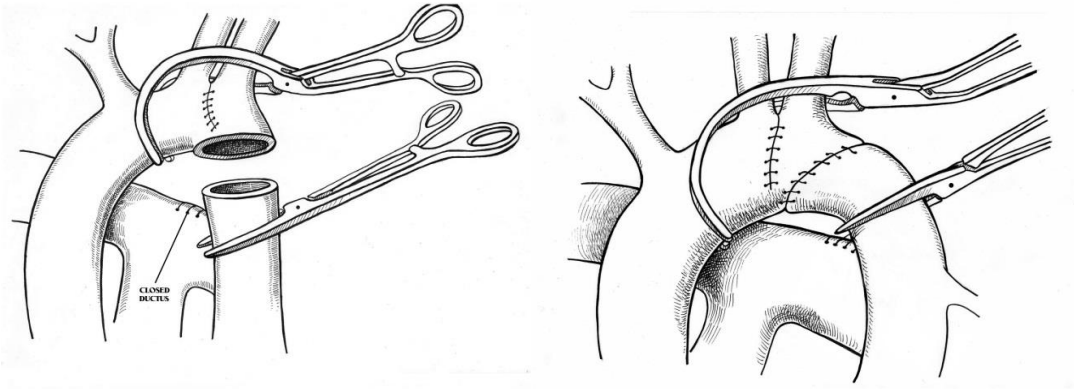

Figure 4, 5

There was no tension in the aorta tissue across the anastomosis as very important outcome this method because we thrifty dissected descending aorta, cut only 1 pair intercostal collaterals. Hemostasis and drainage was applied.

Results

Thirty one patients underwent surgery well, but 1(3,03%) died in the early postoperative period due to arterial bleeding from the tracheobronchial tree. Using modified Amato method gave an opportunity to completely correct hypoplastic distal aortic arch. Mean duration of operation was 154±3,1 min. The non-ischemic (PDA was open) and ischemic aortic clamp times were 28±2,1 min and 25±2,5 min, respectively. ECHO was performed after operation (Table 1). In all patients distal aortic arch plasty revealed significant enlargement of this segment. The median size of aortic arch segments after operation by Z-score were: istmus 2,83; DAA 0,58; PAA - 0,38. The residual systolic gradient pressure on the distal aortic arch was 9,2±1,8mm Hg and on the isthmus was 16±1,6mm Hg. After mean midterm 4,7 year (from 1 to 9 year) in the follow-up still 1 patient (3,03%) was observed with mild DAA hipoplasia (Z-score -0,96), and other 1 (3,03%) patient had remain mild PAA hypoplasia (Z-score -0,86). We haven't any patients with recoarctation in the istmus segment and revealed significant growth of the aortic arch. Median sizes Z-score of aortic arch segments were istmus 0,28; DAA 0,17; PAA -0,11.

Discussion

The original method for enlarging at the distal aortic arch was published 1977. We have made a few modificathion to the original method. Firstly, we created new DAA that means by PDA we have saving perfusion of the lower body, including the kidneys and spinal cord as discussed Dave H. et all and then only resected CoA and EEEA [7, 8, 10]. In original Amato method recomend other way round [1].

We can do this method when we have severe hypoplasia DAA as a part arch with Z-score is ≤ - 2, and diameter it ≤ 5 mm accordingly because when we will make resected CoA and EEEA through the left thoracotomy at first modified Amato plasty have more possibility. There is very important anatomical condition for performing analyzed method by enough distance between TB to LCA (≥6мм) about placement vascular clamp for preservation of blood flow of the brain. If we don't have this anatomical condition we just used CPB including DHCA and SCP as in another cases where severe hypoplasia PAA Z-score is < - 2, after removing CoA used end-to-side anastomosis between descendense of aorta sew in ascendence of aorta as discussed by Brown J. et al, Mery C. et all and Tulzer A. et all. [3, 4, 5].

We had observed distance between LCA and LSA longer as usual in neonates had DAAH and consist of mean 7 mm (from 4 to10) that why encourage difficulties for creating directly

EEEA without previous modified Amato method. This anatomical condition to lead invention of obstruction DAA in remote follow-up period [7, 8, 9, 10].

In 13 cases with CoA and significant septal defects with high pulmonary hypertension we performed at first PA banding. This step helps to prevent pulmonary overcirculation when aorta is clamped. Also newborns with intracardiac anomalies such as CAVC, VSD, SV could have higher mortality in a one stage repair. This method is safety and efficient.

Concusions

Tissues the left carotid artery and the left subclavian artery after plasty give growth to distal arch of aorta in the mid-term period more than 95% of cases. Pulmonary artery banding is performed at first step for hemodynamic stabilization in newborns with CoA and septal defects with HPH.

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