Approach for surgical correction of pulmonary artery coarctation without cardiopulmonary bypass

Tática para cirurgia de correção da coarctação da artéria pulmonar sem uso de circulação extracorpórea

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Abstract

Pulmonary artery coarctation often happens in patients with pulmonary atresia. The correction is usualy on bypass and in the neonatal period, influencing pulmonary artery development and patient prognosis. Three patients with pulmonary atresia depending of PDA where corrected using median sternotomy without cardiopulmonary bypass. The PDA maintained the arterial saturation during Blalock Taussig anastomoses upon the other pulmonary artery. Pulmonary arterioplasty was performed using an autologous pericardium with 7-0 PDS running suture and saturation maintained by Blalock shunt. All patients had good follow up and where discharged with good enlargement of coarctation area.

Descriptors: Pulmonary artery. Pulmonary atresia. Heart defects, congenital. Cardiopulmonary bypass. Pulmonary circulation.

Resumo

A coarctação de artéria pulmonar é comum em pacientes com atresia pulmonar. A correção tem sido com CEC e no período neonatal, quando influencia o desenvolvimento das artérias pulmonares e o prognóstico. Foram corrigidos três pacientes por esternotomia mediana com atresia pulmonar dependentes do ducto arterioso (PCA) sem uso de CEC. O PCA mantinha a saturação durante a confecção do Blalock Taussig na artéria pulmonar contralateral. Arterioplastia foi realizada com sutura de pericárdio autólogo com PDS 7-0 e saturação mantida pelo Blalock. Todos pacientes tiveram boa evolução e alta hospitalar com avaliação de controle demonstrando bom alargamento da área coarctada.

Descritores: Artéria pulmonar. Atresia pulmonar. Cardiopatias congênitas. Circulação extracorpórea. Circulação pulmonar.

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INTRODUCTION

The pulmonary artery stenosis at the insertion site of
the ductus arteriosus, also known as coarctation of the
pulmonary artery was described in 1954 by Sondergaard
[1]. The pulmonary artery stenosis justaductal is extremely
common and can occur in up to 60% of cases with
pulmonary atresia and up to 10% of patients with pulmonary
stenosis [2-4]. Oliveira et al. [5] described in our country, in
a study of 766 catheterizations assessment that there was
pulmonary obstruction in 37.7% of cases with pulmonary
atresia, 8.6% in cases with pulmonary stenosis, 17.2% in
cases of tetralogy of Fallot and 28.3% in cases of right
ventriculcar double outflow tract with pulmonary stenosis.
In cases of pulmonary atresia with atresia of the pulmonary
trunk, the levels of obstruction can reach 75% [2].

Surgical correction of coarctation of the pulmonary
artery should be performed as early as possible, especially
in patients who have indication for univentricular correction
[6]. The completion of correction of coarctation of the
pulmonary artery allows proper development of the
pulmonary tree, favoring the vascularization and
maintenance of low resistance in the pulmonary arteries
[7]. With the delay of surgical treatment, future procedures
may be more complex and with less favorable outcomes
due to the underdevelopment of the lung, which receives
less blood flow [8].

Currently, the treatment of coarctation of the pulmonary
artery has been accomplished even in the neonatal period
and with use of cardiopulmonary bypass in several centers
around the world [6,7,9]. The use of cardiopulmonary
bypass in the neonatal period causes to the child a large
inflammatory stimulation and can double its intravascular
blood volume [10]. Furthermore, it may be necessary to use
more severe hypothermia, in order to decrease the arterial
flow to facilitate the visualization of the operative field,
with the possibility of neurological deficit [11].

Therefore, the aim of this study was to demonstrate the
feasibility and immediate results of surgical correction of
coarctation of the pulmonary artery without cardiopulmonary
bypass, as previously reported by Oliveira et al. [12].

METHODS

In the period between April and October 2008, three
children with coarctation of the pulmonary artery (CoAPA)
underwent surgery at the National Institute of Cardiology
without cardiopulmonary bypass. Two children were female
and one male. The weight of one patient was 2.7 kg and 5
kg of the other two. One child was 7 days old and the other
two 2 and 4 months (Table 1).

Two children presented left justaductal pulmonary
stenosis and one right with a ductus arteriosus nourishing
the right branch of the pulmonary artery. Two presented
pulmonary atresia (PA) with interventricular communication
(IC), but with hypoplastic right ventricle, and one,
pulmonary atresia with IC with possibility of biventricular
treatment, but presented in cyanotic crisis indicating
confection of systemic-pulmonary shunt. All children were
diagnosed with multidetector computed tomography
angiography prior to surgery and underwent examination
of control in the postoperative period.

Surgical technique

The procedure was performed with monitoring of
invasive pressure in the radial artery contralateral to the
subclavian artery used for confection of the systemic-
pulmonary shunt. We used deep venous approach with
double lumen catheter and indwelling catheter. The surgical
approach used in all children was median sternotomy, with
partial resection of the thymus tissue.

The pericardial sac was incised in an inverted T manner,
with removal of a piece of autologous pericardium, kept in
saline solution for reconstruction of the pulmonary artery.

Table 1. Demonstration of clinical, operative and postoperative data of patients undergone surgical
correction of pulmonary artery coarctation.

	Patient 1	Patient 2	Patient 3
Pathology	Pulmonary atresia	Pulmonary atresia	Pulmonary atresia
Age	2 months	7 days	5 months
Gender	Female	Female	Male
Weight	5 kg	2.7 kg	5 kg
Size of the PTFE tube	5 mm	4 mm	4 mm
Blalock side	Right	Left	Right
Type of final correction	Univentricular	Univentricular	Biventricular
Time of hospital stay	6 days	6 days	5 days

PTFE – Polytetrafluoroethylene; kg – kilogram; mm - milimeter

A wide dissection of the great vessels and patent ductus arteriosus (PDA) was performed, exposing clearly the region of coarctation of the pulmonary artery (Figure 1). All children had the PDA dissected carefully to maintain the arterial oxygen saturation during the consfection of systemic-pulmonary shunt on the contralateral pulmonary artery.
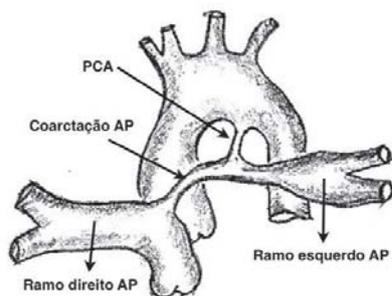

Fig. 1 - Anatomical view of coarctation of the pulmonary artery and its relationship with the patent ductus arteriosus (PDA). The aortic artery is seen posteriorly to the pulmonary artery only for illustration purposes. The aortic and pulmonary vessels are carefully dissected, avoiding injury or spasm of the PDA, which is used to maintain arterial oxygen saturation

It was used infusion of a bolus of 1 mg/kg of heparin, which was peaked if the activated clotting time (ACT) was less than 250 seconds. The pulmonary artery contralateral to the PDA was widely dissected and fixed by yarns. The remnant of the pulmonary artery was ligated and sectioned to prevent distortion of the pulmonary artery branches. The subclavian artery, near the brachiocephalic trunk was dissected and fixed using yarns, receiving then an atraumatic vascular clamp in the lateral position. It was performed a longitudinal arteriotomy of ideal size for anastomosis of the polytetrafluoroethylene (PTFE) tube, previously cut in bevel. The PTFE tube of 4 or 5 mm was anastomosed, end-to-side, on the subclavian artery, using continuous suture with 7-0 polypropylene yarn (Figure 1B). The pulmonary artery received then two straight atraumatic vascular clamps in transverse position, allowing no distortion of the PDA. The systemic-pulmonary shunt was completed with end-to-side implantation of the PTFE tube into the pulmonary artery with continuous suture using 7-0 polypropylene.

During the entire procedure of confection of the systemic-pulmonary shunt, the arterial saturation was maintained by the flow of blood through the PDA at the contralateral pulmonary artery (Figure 2). The clamps of the subclavian and pulmonary arteries were removed, allowing flow through the systemic-pulmonary shunt, which maintained the blood oxygen saturation during the reconstruction of the coarted pulmonary artery.
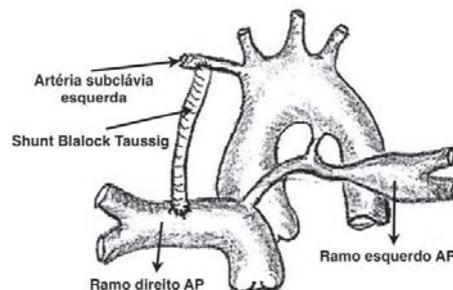

Fig, 2- Confection of systemic-pulmonary shunt, modified Blalock Taussig, of the subclavian artery up to the pulmonary artery contralateral to the PDA with polytetrafluoroethylene (PTFE) tube of 4 or 5 millimeters anastomosed with a continuous suture using 7-0 polypropylene yarn

The PDA was then widely dissected and connected twice with 6-0 polypropylene suture. Then, the PDA was sectioned, allowing wide dissection of the remainder of the contralateral pulmonary artery to the systemic-pulmonary shunt. We used two straight atraumatic vascular clamps, so as to leave wide exposure of the pulmonary artery, which includes the segment of narrowing of the coarctation. During this period, the blood oxygen saturation was maintained by the flow of blood through the systemic-pulmonary shunt, previously confectioned. It was performed a wide longitudinal opening in the pulmonary artery, including the segment of coarctation. The piece of fresh autologous pericardium was used for the enlargement of the pulmonary artery using continuous suture with absorbable polydioxanone (PDS) 7-0 yarn (Figure 3). After the angioplasty with autologous pericardium, the atraumatic vascular clamps were removed, restoring complete blood flow for both pulmonary arteries by the influx of blood through the systemic-pulmonary shunt. Heparinization was maintained by infusion pump for at least 24 hours to avoid the formation of thrombi in segments manipulated.
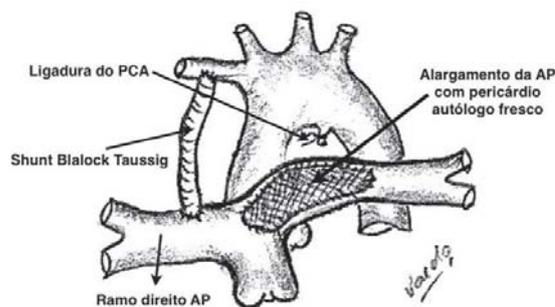

Fig. 3 - View of wide longitudinal enlargement of the area of coarctation of the pulmonary artery using a graft of fresh autologous pericardium with a continuous suture of absorbable 7-0 polydioxanone (PDS) yarn. The PDA is ligated and sectioned between double ligature with 6-0 polypropylene, to prevent distortion of the pulmonary branches

RESULTS

Two PTFE tubes of 4 mm and 5 mm were implanted, using the technique described above. All surgeries were performed with excellent hemodynamic stability and without cardiopulmonary bypass. All patients presented good performance and discharge from hospital, one with 5 and two with 6 days postoperatively (Table 1). All patients underwent control assessment with good enlargement of the CoAPA region assessed by multidetector computed tomography angiography (Figure 4). The children present no bleeding due to maintenance of heparin.

DISCUSSION

Coarctation of the pulmonary artery is a rare disease first described more than 50 years ago and very common in cases with some degree of stenosis of the right ventricular outflow tract [1-3]. Luhmer et al. [13] has shown that 36%, nine out of 25 neonates with cyanosis due to obstruction of the right ventricular outflow tract, presented justaductal pulmonary stenosis associated with the invasion of ductal tissue in the pulmonary artery. Due to lack of knowledge and/or investigation of obstructions at the level of the pulmonary arteries, many children have been only
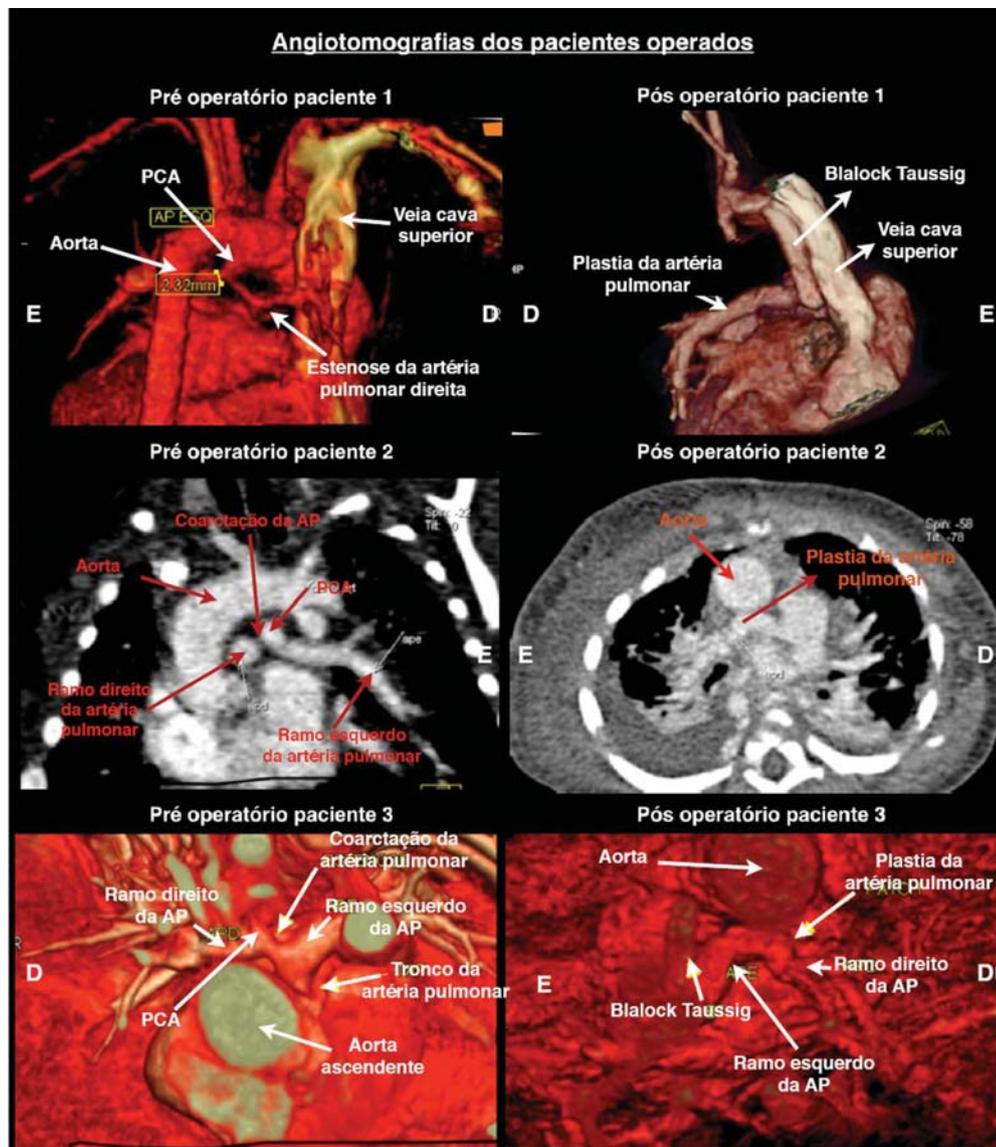

Fig. 4 - View of multidetector CT angiography in patients undergoing surgical correction of coarctation of the pulmonary artery

diagnosed only later, worsening the prognosis, especially in cases progressing to the Fontan operation.

The need for early surgery, especially in cases with indication of univentricular repair is mandatory and advocated by several centers around the world [6,7,9,14]. The main objective is to restore adequate flow to both pulmonary arteries. Thus, it may prevent unilateral hypoplasia of the pulmonary arterial tree and therefore the growth of tortuous bronchial collateral arteries [13].

Surgical correction with enlargement of the coarctation area using autologous pericardium is performed by several groups [6,7,9]. The surgery is usually performed with cardiopulmonary bypass, which leads to an exacerbation of the inflammatory response with increased hospital stay and complications [10]. The period of hospital stay in this group of three patients was, at maximum, of 6 days (Table 1) extremely short when compared with an average of 13.5 ± 12.3 days, only of stay in the ICU, reported by other groups that perform the procedure with cardiopulmonary bypass [9].

The possibility of confection of the systemic-pulmonary shunt using the PDA to maintain arterial oxygen saturation is essential for performing the procedure without cardiopulmonary bypass [12]. For this, one should dissect the anatomical structures without the occurrence of injuries, spasms or distortion of the PDA during the preparation and anastomoses of the systemic-pulmonary shunt (Figure 1C).

CONCLUSIONS

Even in a group with a small number of patients, this tactic seems to be favorable for the treatment of coarctation of the pulmonary artery, avoiding the use of cardiopulmonary bypass and its deleterious effects. The accomplishment of surgery in the neonatal period provides smooth enlargement of the pulmonary artery stenosis with the possibility of good development, especially in the field of candidates for Fontan operation.

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