Neonatal pulmonary artery banding does not compromise the short-term function of a Damus–Kaye–Stansel connection

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Abstract

Background: The surgical approach of neonates with a functionally univentricular heart, transposition of the great arteries and excessive pulmonary bloodflow remains a challenge. Pulmonary artery banding remains a valuable option, but may induce ventricular hypertrophy, restriction of the bulboventricular foramen and dysplastic changes of the pulmonary valve. These secondary changes might compromise a later Damus–Kaye–Stansel connection because of pulmonary regurgitation but also a subsequent Fontan repair because of ventricular hypertrophy. The aim of this study is to investigate whether a previous pulmonary artery banding might compromise the function of a Damus–Kaye–Stansel connection.

Methods: Thirteen neonates underwent pulmonary artery banding for functionally univentricular heart, transposition of the great arteries and pulmonary hypertension. Coarctation repair was associated in seven patients. All but one survived the operation. The twelve survivors underwent at a second stage a Damus–Kaye–Stansel connection after a mean interval of 1.1 years. The length of this interval was dictated by the degree of ventricular hypertrophy, the restriction of the bulboventricular foramen and by the degree of cyanosis. The Damus–Kaye–Stansel connection was constructed without any foreign material and with resorbable sutures. Associated procedures were: Glenn/hemi-Fontan (8 pts), Blalock-shunt (2 pts), biventricular correction with a homograft (1 pt), Fontan repair (1 pt). Four patients underwent successfully a Fontan repair at a third stage; seven patients are waiting for such repair.

Results: All patients survived the second and third stage of this surgical approach. The mean follow-up after the Damus–Kaye–Stansel connection was 2.5 years. Echocardiography at the last follow-up revealed: PR grade 0 (1 pt), grade 1 (8 pts), and grade 2 (3 pts). All patients, including those who underwent a definitive repair, are doing extremely well.

Conclusion: This experience demonstrates that a neonatal pulmonary artery banding does not compromise the function neither of a Damus–Kaye–Stansel connection nor a Fontan repair.

Keywords: Univentricular repair; Fontan repair; Subaortic stenosis; Banding pulmonary artery

1. Introduction

A Fontan repair remains the ultimate goal in patients with a functionally univentricular heart (UVH). This remains a challenge especially in patients with a univentricular heart with transposition of the great arteries (TGA), excessive pulmonary bloodflow and pulmonary hypertension (PHT). A modified Norwood procedure has been proposed for those patients, but carries a high perioperative risk.

Pulmonary artery banding (PAB) remains a valuable option, but may induce or accelerate ventricular hypertrophy, restriction of the bulboventricular foramen and dysplastic changes of the pulmonary valve. These secondary changes might not only compromise a later Damus–Kaye–Stansel (DKS) because of pulmonary regurgitation (PR) but also a subsequent Fontan repair because of ventricular hypertrophy. The aim of this study is to investigate whether a PAB might compromise the ultimate later stages to a Fontan repair.

2. Materials and methods

Thirteen consecutive patients underwent a PAB as a first stage because of UVH with TGA and PHT between January 1993 and February 1998. Through a left thoracotomy a PAB was performed to achieve a distal PA systolic pressure around 50% of systemic pressure with an arterial saturation of 75–85% with an inspired oxygen fraction of 0.60. The band was located just proximal of the PA bifurcation and was fixed with two 5-0 prolene stitches placed at opposing...
sites of the arterial wall. In seven of these 13 patients a coarctation repair (three subclavian flaps and four extended aortic arch repairs) were associated to the PAB.

Twelve survivors underwent at a second stage of DKS connection after a mean interval of 1.1 years (4 weeks–50 months). The length of this interval was dictated by the degree of ventricular hypertrophy, the restriction of the bulboventricular foramen and by the degree of cyanosis. The DKS connection was constructed using conventional cardiopulmonary bypass with bicaval cannulation and crystalloid cardioplegia. In the first four patients the DKS connection was created by implanting the transected PA into the ascending aorta. The other eight patients underwent a modified technique. Both great vessels were transected at the level of the previously placed band and sutured side-by-side over one third to one half of their circumference using resorbable suture material. The ascending aorta was then-after sutured in an end-to-end fashion to this unified ‘bivalved’ artery. In three out of these eight patients a gusset of pericardial tissue was used to enlarge the ascending aorta. Associated procedures were: Glenn/hemi-Fontan (8 pts), a central aorto-pulmonary shunt (2 pts), biventricular homograft correction (1 pt) and Fontan repair (1 pt).

Four patients underwent successfully a Fontan repair (two extracardiac and two intra-atrial lateral tunnels) at a third stage; seven patients are waiting for such repair.

All patients were followed by the same echocardiographer at three months intervals with echo-doppler examination. The following scoring system was used to quantify semilvalvular leaks: grade 0 (no leak), grade 1 (trivial), grade 2 (slight), grade 3 (moderate) and grade 4 (severe). Intermediate leakages between two scores were upgraded to the highest score.

3. Results

All patients survived the second and third stage of this surgical approach. The mean follow-up after the DKS connection was 2.5 years (1.3 month–4.9 years). Echo-doppler examination at regular intervals documented laminar flow across the DKS connection without any gradient between the LV and the ascending aorta in 11 pts. One patient developed a 24 mmHg systolic gradient after a follow-up of 2.9 years. Regression of ventricular hypertrophy was documented in all 12 pts.

Eight out of ten patients presented with a 1 grade PR before the DKS connection. Pulmonary (neo-aortic) regurgitation (PR) at the last FU examination revealed the following scores: grade 0 (1 pt), grade 1 (8 pts), and grade 2 (3 pts). No patients presented with grade 3 and/or grade 4 leakage. No progression of leakage was noticed during subsequent examinations.

Regurgitation of the native aortic valve showed the following distribution: grade 0 (6 pts), grade 1 (6 pts).

All patients, including those with a Fontan repair (5 pts) and one patient with a biventricular correction, are in excellent clinical condition.

4. Discussion

The surgical approach of the neonate with UVH, TGA and PHT remains a challenge. Most authors will agree that a univentricular repair will guarantee the best long term results.

Biventricular repair with ventricular septation was abandoned because of an unacceptable high perioperative mortality and a high incidence of complete heart block [1,2]. A modified Norwood procedure is another surgical alternative. Very few centers however have adopted this procedure for this subset of patients. Mosca and associates report excellent perioperative results (hospital mortality of 8%) in 38 patients with five late deaths [3].

We embarked in a program of univentricular repair because of our suboptimal results with the Norwood procedure and because of excellent results reported in neonates with UVH, TGA and PHT [4–6]. Currently we master the Norwood but still prefer PAB in the approach of this particular pathology because of the following reasons: PAB is less invasive, the perioperative morbidity and mortality is lower, the growth of the pulmonary arteries after PAB will be better than after a central aorto-pulmonary shunt.

PA banding (PAB) is a valuable option in the staged approach to univentricular repair, but can induce ventricular hypertrophy, fasten restriction of the bulboventricular foramen [7–9] and lead to dysplastic changes of the pulmonary valve. These secondary changes might not only compromise a later Damus–Kaye–Stansel because of PR but also a subsequent Fontan repair because of ventricular hypertrophy [10].

The technique of pulmonary banding is crucial in order to be able to adopt this staged palliation. The band should be placed away from the pulmonary valve to avoid dysplastic changes of the semilunar valves which might lead to valve regurgitation. Migration of the band can lead to pulmonary branch stenosis. Therefore fixation of the band to two opposite sites of the pulmonary artery wall seems to be very helpful. Our experience as well as the experience of other groups have shown that an optimal PAB does not interfere with valve function after DKS connection [11,12].

The development of subaortic obstruction should be monitored very carefully. Definite criteria to predict subaortic obstruction are difficult to develop. The measurement of a gradient across the bulboventricular foramen seems not adequate since ventricular unloading after Fontan correction can aggravate an existing insignificant gradient [13]. Therefore the slightest suspicion of obstruction, (i.e. smaller diameter of the bulboventricular foramen compared to the diameter of the aortic annulus) is sufficient to advocate a DKS procedure.

Enlargement of the bulboventricular foramen is a poor
option since it might lead to instability of the aortic valve, decreased ventricular function, destabilization of the mechanical contractile function of the UVH, potential of surgical heart block. We have used this approach in two patients with disappointing results: progressive aortic regurgitation in one and severe ventricular arrhythmia in another patient.

The use of a neonatal arterial switch was never considered by us as an option because of the technical problems created by the mismatch of both great vessels and/or the possibility of later peripheral pulmonary stenosis resulting from the anterior position of the pulmonary artery.

The timing of a DKS connection is of the utmost importance since an obstruction at the level of the bulboventricular foramen can develop very soon after banding of the PA as documented in four of our 12 patients where this interval was shorter than 3 months. This interval was also shorter in those patients who underwent a coarctation repair at the time of banding [14].

The technique of the DKS is important in order to obtain optimal valve function without regurgitation [13]. In our earlier experience (4 pts) we implanted the transected pulmonary artery in the ascending aorta in an end-to-side fashion. In the remaining patients the transected ascending aorta was sutured end-to-end to the bivalved constructed proximal aorta and pulmonary artery. We believe that this technique is superior since it avoids unbalanced traction on the sinotubular junction on both vessels and decreases the risk of obstruction and/or regurgitation. With this technique pericardial patching was only needed in patients with a small ascending aorta. One patient with Taussig±Bing transposition underwent a biventricular repair in association with the creation of a DKS connection. This patient did not develop aortic regurgitation (follow-up: 56 months) although there is some evidence that this subgroup of patients is known to develop a regurgitation [15].

This experience demonstrates that a neonatal PAB does not compromise the function neither of a DKS connection nor a Fontan repair. A drawback of this study is the short follow-up. Therefore carefully monitoring of those patients with minimal to slight valve regurgitation will be necessary because this might endanger the ultimate univentricular repair.

Addendum

Two more patients underwent successfully a Fontan repair after submission of this manuscript.

References


