Efficacy of Damus-Kaye-Stansel procedure in patients with univentricular heart associated with ventriculo-arterial discordance and excessive pulmonary blood flow

Yoichi Kawahira*, Kyoichi Nishigaki, Yoshito Maehata

Department of Pediatric Cardiovascular Surgery, Osaka City General Hospital, 2-13-22 Miyakojimahondori, Miyakojima-ku, Osaka 534-0021, Japan

Received 24 November 2010; received in revised form 12 January 2011; accepted 13 January 2011

Abstract

Pulmonary artery banding (PAB) and ventriculo-arterial discordance (VAD) were reported to be risk factors of subaortic stenosis in univentricular heart. The aim of this study was to evaluate efficacy of Damus-Kaye-Stansel (DKS) anastomosis. Of all 89 patients undergoing total cavo-pulmonary connection (TCPC) in our center since April 1996, 38 had VAD with high pulmonary blood flow, and had received PAB. Twenty-one of 38 had undergone DKS anastomosis due to subaortic stenosis or due to morphological hypertrophy of the outlet septum (DKS group); the other 17 had not yet (no-DKS group). Percentage end-systolic volume of the systemic ventricle and percentage subaortic lesion in both groups significantly decreased after TCPC (P<0.01). Pressure gradient across systemic outflow tract after TCPC was low in both groups at rest. The gradient in DKS group did not differ from those in control group with ventriculo-arterial concordance (VAC) (P>0.1). Ventricular outflow tract after DKS anastomosis might behave like that of VAC even when dobutamine is loaded, suggesting that the anastomosis should be carried out in many patients with this entity even if stenosis across systemic ventricular outflow is not significant, considering possible stenosis in the future.

© 2011 Published by European Association for Cardio-Thoracic Surgery. All rights reserved.

Keywords: Damus-Kaye-Stansel procedure; Subaortic stenosis; Univentricular heart; Ventriculo-arterial discordance

1. Introduction

Ventriculo-arterial discordance (VAD), excessive pulmonary blood flow, and pulmonary artery banding (PAB) have been reported as risks of subaortic stenosis in patients with univentricular heart (UVH) [1–5].

Because all patients with such risks do not represent significant subaortic stenosis, enlargement of the systemic outflow tract such as Damus-Kaye-Stansel (DKS) anastomosis is not always carried out [6].

We have carried out DKS anastomosis for the entity with significantly functional or morphological subaortic stenosis. The aim of this study was to clarify efficacy of DKS anastomosis at rest and during cardiac output increased, and operative indication for this entity.

2. Patients and methods

Thirty-eight patients with UVH, VAD with excessive pulmonary blood flow, received PAB as a first palliation in our center since April 1996. PAB was carried out at the mean age of 35 days after birth, concomitantly arch repair for coarctation or interruption of the aorta was done in 17. The mean circumference of the tape was body weight x (19.3 ± 2.6) mm.

Then 37 patients had received bidirectional Glenn shunting (BDG) and 34 patients had received total cavo-pulmonary connection (TCPC) at the age of 5.0 ± 3.9 years so far.

Of all 38 patients, 21 had undergone DKS anastomosis due to functional or morphological subaortic stenosis (DKS group). DKS anastomosis was carried out concomitant with BDG in 15, before TCPC in one, concomitant with TCPC in two. The other 17 had not DKS anastomosis yet (no-DKS group).

Diagnoses in DKS group were double outlet right ventricle (DORV) in 10, double inlet left ventricle (DILV) in six, tricuspid atresia (TAIC) in two, atrio-ventricular discordance (AVD) ± VAD in two, and transposition of the great arteries (TGA) in one, and in no-DKS group were DORV in 10, TGA in three, TAIC in two, and VAD±AVD in two. Associated cardiac anomalies were coarctation or interruption of the aorta in nine of DKS group and eight of no-DKS group.

Cardiac catheterization was carried out 1.5 ± 1.3 months before BDG, 1.8 ± 1.0 months before TCPC and 13.3 ± 13.5 months after TCPC. Percentage SVEDV was measured using modified Simpson method. Percentage sub-aortic dimension (SAD), which was the ratio of diameter of the systemic outflow divided by the normal aortic valve dimension (16.6 ± BSA0.5), was measured using ventriculogram. Cardiac index was calculated by Fick method.
Dobutamine (DOB) loading test was carried out at the dose of 10 \( \mu \)g/kg/min during cardiac catheterization after TCPC. Five minutes to 10 min after DOB infusion, pressure gradient across systemic outflow tract (PGOT) was measured. This test was carried out in seven of DKS group and in eight of no-DKS group and nine patients with ventriculo-arterial concordance (VAC) with systemic left ventricle (control group), 5.1 ± 3.0 years after TCPC. Heart rate was significantly elevated from 95.1 ± 19.2/min before DOB to 131.3 ± 32.5/min after DOB (P < 0.01). Systolic blood pressure was also significantly elevated from 104.9 ± 7.0 mmHg before DOB to 135.7 ± 20.1 mmHg after DOB (P < 0.01).

Follow-up term was 8.4 ± 2.6 years after TCPC. To compare parametric data between two groups, Wilcoxon test was used, and ANOVA and Bonferroni’s multiple comparison test were also used for parametric data among three groups.

3. Results

There were no operative and late deaths after DKS anastomosis. No patients had significant aortic regurgitation so far.

Percentage SVEDV in DKS group was 250 ± 51% before BDG, 206 ± 60% before TCPC and 99 ± 37% after TCPC. Similarly, in no-DKS group was 224 ± 49% before BDG, 149 ± 38% before TCPC, and 98 ± 27% after TCPC. Percentage SVEDV in both groups significantly decreased from before BDG to postTCPC (P < 0.01).

Percentage SAD in DKS group was 78 ± 10% before BDG, 69 ± 21 before TCPC and 54 ± 29 after TCPC. Similarly, in no-DKS group (Fig. 1) was 117 ± 28 before BDG, 78 ± 24 before TCPC, and 62 ± 11 after TCPC. Percentage SAD in both groups also similarly significantly decreased from before BDG to postTCPC (P < 0.01).

PGOT after TCPC was low in both groups (3.1 ± 2.1 mmHg in DKS group, and 7.2 ± 6.8 mmHg in no-DKS group) (Fig. 1). No patients in DKS group had PGOT > 10 mmHg after TCPC, however, three (17.6%) in no-DKS group had. Cardiac index in both groups did not significantly differ (3.7 ± 0.9 l/min/m^2 in DKS group and 3.5 ± 0.6 l/min/m^2 in no-DKS group).

DOB loading test revealed that PGOT became significantly larger after DOB infusion in all three groups (P < 0.01, from 3.5 ± 2.9 mmHg to 12.1 ± 10.7 mmHg in DKS group; P < 0.01, from 10.5 ± 6.6 mmHg to 28.9 ± 14.4 mmHg in no-DKS group; and P < 0.01, from 1.8 ± 2.7 mmHg to 10.8 ± 5.5 mmHg in control group) (Fig. 2).

Control group did not have PGOT > 10 mmHg before DOB, nor PGOT > 20 mmHg after DOB. Also in DKS group, no patients had PGOT > 10 mmHg before DOB, and only one (14.3%) had PGOT > 20 mmHg after DOB. However, three (37.5%) in no-DKS group had PGOT > 10 mmHg before DOB and five (62.5%) had PGOT > 20 mmHg after DOB.

PGOT after DOB infusion was significantly lower in DKS group than in no-DKS group (P < 0.01), however, it did not differ from that in control (P > 0.1).

4. Discussion

Systemic outflow tract obstruction in patients with UVH causes hypertrophy of the ventricular muscles, which has adverse effects for TCPC [1–5]. As risks progressing the obstruction, excessive pulmonary blood flow requiring PAB, VAD and so on are reported [1–5]. Patients with significant PGOT are indicated for relief of the stenosis by DKS or myectomy, however, surgeons often prophylactically carry out these procedures also for patients with morphologic features such as hypertrophied outlet septum without significant pressure gradients. Exact surgical indication for the procedure is not clear yet.

Our results showed that percentage SVEDV and percentage SAD were decreased after BDG and TCPC. Volume unloading of the systemic ventricle and decrease of cardiac index after right heart bypass might effect to decrease percentage SVEDV, insulting to decrease of percentage SAD. That might cause significant subaortic stenosis after BDG or TCPC.

Since patients in DKS group had significant subaortic stenosis or morphologic features of the hypertrophied outlet septum, there were significant differences in patients’ characteristics between DKS and no-DKS group; percentage SAD before BDG was significantly lower in DKS group than in no-DKS group as shown in the results. However, PGOT

Fig. 1. Changes of PGOT in DKS group and in no-DKS group showing that the gradient after TCPC was low in both groups. No patients in DKS group had PGOT > 10 mmHg after TCPC, however three (17.6%) in no-DKS group had.

DKS, Damus-Kaye-Stansel; TCPC, total cavo-pulmonary connection; PGOT, pressure gradient across systemic outflow tract; BDG, bidirectional Glenn shunting.

Fig. 2. Changes of PGOT before and after DOB infusion in DKS group, no-DKS group and control showing that the gradient before and after DOB in DKS group was significantly lower than that in no-DKS group (P < 0.01), and did not differ from that in control with atrio-ventricular concordance (P > 0.1). DKS, Damus-Kaye-Stansel; DOB, dobutamine.
after TCPC did not significantly differ between DKS group and control. These data showed that DKS procedure was very helpful to relieve possible stenosis across the ventricular outflow tract, and that the ventricular outflow tract in VAD after DKS procedure might behave similar to that in VAC even during DOB infusion.

In no-DKS group, 17.6% of all patients had PGOT > 10 mmHg at rest after TCPC and 62.5% had PGOT > 20 mmHg after DOB, although no patients had PGOT > 10 mmHg before TCPC. A patient in no-DKS group with atrio-ventricular discordance and the hypoplastic left ventricle, whose outlet septum was not hypertrophic before BDG, had PGOT of 8 mmHg at rest after TCPC. However, ventriculogram after TCPC demonstrated the well-hypertrophic outlet septum, and PGOT became >50 mmHg at DOB test. Patients without significant stenosis across outflow tract at rest often show significant stenosis during DOB test. Patients with arch repair for coarctation or interruption of the aorta are reported to often have hypertension during DOB loading test or during exercise [7], and residual structural or functional aortic arch defects might be responsible for exercise induced hypertrophy [8]. Similarly, mild stenosis during DOB test in no-DKS group might result from mild obstruction of the outflow tract. And the mild stenosis might induce ventricular hypertrophy after TCPC, which is not good for hemodynamics after TCPC [1–5]. In this point, DKS procedure, which would remove malignant potential in the future from this entity, might have another advantage. Patients with VAD and excessive pulmonary blood flow without subaortic stenosis might have possible subaortic stenosis after volume unloading of the ventricle. We encourage DKS procedure for most of these patients with VAD and excessive pulmonary blood flow requiring PAB.

As procedures releasing subaortic stenosis, DKS procedure, subaortic myectomy have been reported. We have four patients undergoing subaortic myectomy for these entities during the same duration; one of four had residual stenosis after procedure. Subaortic myectomy was carried out for these four because DKS procedure impaired blood flow of the coronary arteries or the stenosis was limited at subaortic lesion. DKS procedure sometimes has complications of coronary artery kinking or aortic regurgitation [9]. However, we should not hesitate to use DKS procedure when we can carry out this procedure.

Another concern is whether conventional DKS with end-to-side fashion or double-barrel DKS should be carried out. We had carried out conventional DKS. It might be important not to distort anastomosis at DKS, which might result in neo-aortic regurgitation, residual stenosis, and coronary artery kinking. So that, double-barrel DKS has been recently carried out in patients with twisted relationship between great arteries. The creation of a double barrel type of anastomosis seems to be straightforward, and would not have less complication.

In summary, DKS anastomosis might be feasible for UVH with VAD associated with excessive pulmonary blood flow even when DOB was loaded as well as at rest. DKS anastomosis should be carried out in most patients with these morphologies.

References