Which type of conduit to choose for right ventricular outflow tract reconstruction in patients below 1 year of age?

Keti Vitanova, Julie Cleuziou, Jürgen Hörer, Jelena Kasnar-Samprec, Manfred Vogt, Christian Schreiber and Rüdiger Lange

OBJECTIVES: Reconstruction of the right ventricular outflow tract (RVOT) with a conduit in patients below 1 year of age remains a matter of concern due to limited availability and durability of conduits. We sought to analyse the freedom from conduit exchange in this subgroup of patients by comparing different conduits.

METHODS: Data of 145 consecutive patients below 1 year of age, requiring a conduit for RVOT reconstruction between 1994 and 2011 were reviewed. The endpoints of the study were defined as: 'conduit exchange for any reason', 'at least moderate conduit stenosis' and 'at least moderate insufficiency'.

RESULTS: Homografts, bovine jugular vein conduits (Contegra) and porcine-valved Dacron conduits (Hancock) were implanted in 62 (43%), 35 (24%) and 48 (33%) patients, respectively. The mean conduit diameter was 12.9 ± 1.3 mm. A conduit exchange was necessary in 72 patients (55%) at a median time of 5.9 years [1.1–10.8]. The rate of freedom from conduit exchange at 5 years was 69.4 ± 6.6, 59.4 ± 8.7 and 53.8 ± 7.4%, respectively (P = 0.4). The rate of freedom from at least moderate stenosis was 85.4 ± 5.6, 75.1 ± 9.1 69.1 ± 7.9% at 5 years and 59.2 ± 11.1, 35.8 ± 12.0, 49.7 ± 10.1% at 10 years, for homografts, Contegra and Hancock conduits, respectively. The rate of freedom from at least moderate conduit insufficiency was 91.7 ± 4, 74.6 ± 9.1, 86.9 ± 7.4% at 5 years and 64.8 ± 14.1, 44.2 ± 13.7, 52.1 ± 14.2% at 10 years, for homografts, Contegra and Hancock conduits, respectively. Patients with a Contegra conduit developed moderate conduit stenosis or insufficiency faster than patients with a homograft (P = 0.01). Age below 1 month and heterotopic implantation of the conduit emerged as risk factors for conduit exchange in the univariate analysis (P = 0.05, P = 0.02, respectively). There was no significant influence of the conduit type, conduit size, z-score or the body surface area. In the multivariate analysis, heterotopic implantation emerged as the only risk factor for conduit exchange (P = 0.02, hazard ratio = 1.6, 95% confidence interval = 1.0–2.7).

CONCLUSIONS: Homografts, bovine jugular vein conduits and porcine-valved Dacron conduits exhibit equal durability after implantation in patients below 1 year of age independent of their size. Nonetheless, moderate conduit stenosis or insufficiency develops earlier in patients with a Contegra conduit. Conduit placement in the neonatal period and implantation in a heterotopic position shortens the durability.

Keywords: Neonate • Congenital heart disease • Right ventricular outflow tract

INTRODUCTION

The use of valved conduits for the reconstruction of the right ventricular outflow tract (RVOT) has made the anatomical correction of many complex heart defects possible. Different types of biological conduits are available but all have limited availability and durability in common.

Homografts are commonly used and have well-known characteristics. Especially pulmonary homografts show good long-term results [1, 2]. However, their restricted availability, particularly in small sizes, has led to the necessity of searching for alternatives. To enhance the supply of small-sized homografts, a valid option is to reduce adult homografts in size by bicuspidization [3, 4]. The other option is to use commercially available xenografts [3, 4] The Hancock porcine-valved Dacron conduit (Medtronic, Minneapolis, MN, USA) has shown good results regarding durability but requires caution in neonates due to the rigidity of the Dacron tube graft [5]. In the mid-term, Contegra bovine jugular vein conduits (Medtronic, Minneapolis, MN, USA) yield comparable results to homografts with the advantage of easy handling [6].

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However, small conduits with a diameter <15 mm were found to have a restricted durability [7, 8]. In order not to confound those factors, we analysed only patients below 1 year of age or those receiving conduits below 15 mm in diameter.

Since corrective surgery is increasingly being performed in early infancy, the search for an adequate conduit for this patient group is crucial. To our knowledge, there are only a few reports in the literature about conduit performance with a focus on neonates and infants [9, 10]. The aim of this study was to evaluate the durability of different conduits in patients below 1 year of age and in patients who received a conduit of 15 mm or less for the reconstruction of the RVOT.

**METHODS**

**Patient population**

The retrospective study includes all consecutive patients who underwent a conduit implantation for RVOT reconstruction between 1994 and 2011 at the German Heart Centre Munich. Patients were identified from the departmental database. Inclusion criteria for the study were ‘age below 1 year’ and/or ‘conduit size ≤15mm’. The implanted conduits were:

(i) Cryopreserved aortic and pulmonary homografts, full-sized and bicuspidized.
(ii) Bovine jugular vein conduits (Medtronic, Contegra).
(iii) Porcine-valved Dacron conduits (Medtronic, Hancock).

The endpoint of the study was defined as ‘conduit exchange for any reason’. The endpoint was achieved if at least a moderate conduit stenosis or a moderate conduit insufficiency was present, or a thrombosis or an endocarditis was diagnosed. Assessing conduit durability from the time of implantation to explantation is imprecise due to inconsistent decisions on the ideal time of conduit exchange. Therefore, two further endpoints were defined: ‘first description of at least moderate conduit stenosis’ and ‘first description of at least moderate conduit insufficiency’.

**Operative data**

Median sternotomy was performed and cardiopulmonary bypass was established through aortic and bicaval venous cannulations using mild hypothermia at 34°C. Previously inserted shunts were taken down and the conduit was placed between the right ventricle (RV) and the pulmonary artery (PA). To minimize the risk of sternal compression, the conduit was tailored very near to the valve and positioned as distal as possible to the pulmonary bifurcation. The z-scores of the conduits were estimated according to the nomograms published by Zilberman et al. [11]. In patients undergoing a Rastelli operation or a correction of a common arterial trunk (CAT), the conduit was placed in a heterotopic position. In all other patients, the conduit was placed in an orthotopic position. Decision on which conduit to choose was dependent on availability and at the discretion of the attending surgeon but independent of the diagnosis. Pulmonary augmentation was not a routine procedure using Contegra conduits. Homografts were extended with Polytetrafluoroethylene or double velour woven Dacron tube grafts to facilitate the proximal anastomosis with the RV.

**Follow-up**

All patients were reviewed regularly at our outpatient clinic or by the referring paediatric cardiologists. All medical reports including serial echocardiographic data were reviewed.

On echocardiography, conduit stenosis was graded by measuring the maximum velocities with a continuous doppler across the conduit and by calculating the pressure gradients across the RVOT. The calculation of the pressure gradients was performed with the modified Bernoulli equation. Stenosis was graded as follows: 1 = mild, peak velocity <3 m/s and peak gradient <36 mmHg; 2 = moderate, peak velocity 3–4 m/s, peak gradient 36–64 mmHg; 3 = severe, peak velocity >4 m/s, peak gradient >64 mmHg [12].

Conduit insufficiency was graded by mapping the dimensions of the insufficiency jet with colour flow doppler echocardiography. This was graded from 0 to 4 as follows: 0 = none, 1 = trivial, 2 = mild, 3 = moderately, 4 = severe, according to the guidelines for echocardiography [12].

**Statistical analysis**

Statistical analysis was performed using SPSS 21.0 software (SPSS, Inc., Chicago, IL, USA). Frequencies are given as absolute numbers and percentages. Comparisons for categorical variables were calculated with the two-tailed χ²-test, or when appropriate Fisher’s exact test. Continuous data are given as medians with ranges or as means with standard deviation. Comparisons for continuous variables were calculated with the t-test for independent samples. The Kaplan–Meier method was used to estimate the freedom from events. The time of conduit implantation was defined as time point zero. Differences between groups were calculated with the Log-Rank test. Risk factors for a conduit exchange were analysed with a linear univariate and multivariate Cox regression Model. For all tests, a P ≤ 0.05 was considered significant. A multivariate analysis was only performed between variables that had a P-value of ≤0.1.

**RESULTS**

**Patients**

Homografts (aortic n = 30, pulmonary n = 32) were implanted in 62 (43%) patients, Contegra conduits in 35 (24%) and Hancock conduits in 48 (33%) patients. Forty-three percent of the homografts were bicuspidized (n = 27). There was no significant difference in demographic data between patients receiving different conduits. Patients with congenital aortic stenosis requiring a Ross operation did not receive a Hancock conduit (P = 0.01). Patient characteristics are represented in Table 1.

In 81 patients (56%), the conduit implantation was performed as part of a primary correction of the underlying disease. The other 64 patients (44%) had undergone a palliative procedure before the conduit implantation. The conduit was implanted in a heterotopic position in 63 patients (43%) and in an orthotopic position in 82 patients (56%). Patients receiving a Contegra conduit required a longer aortic clamping time (P = 0.003). The operative data and the conduit characteristics are depicted in Table 2.

**Survival**

The early mortality rate within 30 days after the conduit implantation was 10% (n = 15), including 5 patients who died...
intraoperatively from myocardial failure. Five patients developed pulmonary hypertension with right ventricular failure, 3 patients had ventricular fibrillation and in 2 patients the reason for death remains unknown. There was no 30-day mortality after the year 2000. The late mortality rate beyond 30 days was 3% (n = 5), 3 patients with a Hancock conduit and 2 patients with a homograft. Three patients developed a septic shock after a feverish infection and 1 patient died from recurrent convulsive seizures. In 1 patient, the reason of death remains unknown.

The study population consists of 130 survivors, 55 with a homograft, 31 with a Contegra conduit and 44 with a Hancock conduit. The median follow-up time is 9.3 years [8.3–10.3]. The patient survival rate was 85.3±4.5, 88.6±5.4 and 89.1±4.6% after 10 years for homografts, Contegra and Hancock conduits, respectively (P = 0.9, Fig. 1).

Conduit performance

The rate of freedom from at least moderate stenosis was 85.4±5.6, 75.1±9.1, 69.1±7.9% at 5 years and 59.2±11.1, 35.8±12.0, 49.7±10.1% at 10 years, for homografts, Contegra and Hancock conduits, respectively. The rate of freedom from at least moderate conduit insufficiency was 91.7±4, 74.6±9.1, 86.9±7.4% at 5 years

Table 1: Patients’ characteristics for 145 patients requiring a right ventricular outflow tract reconstruction

| Variable               | Homograft, n = 62 | Contegra, n = 35 | Hancock, n = 48 | P-value |
|------------------------|-------------------|------------------|----------------|---------|
| Demographics           |                   |                  |                |         |
| Age (months)           | 3.9 [8.8 days to 11.2 months] | 4.0 [11.8 days to 11.8 months] | 3.6 [8.8 days to 11.7 months] | 0.9     |
| Weight (kg)            | 4.6 [1.7–9.5]     | 4.2 [2.2–15.4]   | 4.3 [2.5–8.8]  | 0.7     |
| Body surface area (cm²)| 0.28 ± 0.08       | 0.29 ± 0.1       | 0.28 ± 0.06    | 0.6     |
| Diagnosis              |                   |                  |                |         |
| PS/PA + VSD, n (%)     | 16 (41.0)         | 9 (23.0)         | 14 (35.8)      | 0.5     |
| CAT, n (%)             | 22 (44.0)         | 9 (18.0)         | 19 (38.0)      | 0.4     |
| TOF, DORV (TOF type), n (%) | 14 (40.0)     | 10 (28.5)        | 11 (31.4)      | 0.4     |
| TGA + PS + VSD, n (%)  | 2 (33.3)          | 2 (33.3)         | 2 (33.3)       | 0.6     |
| AS/AI, n (%)           | 5 (50.0)          | 5 (50.0)         | 0              | 0.01    |
| AVSD + TOF, n (%)      | 0                 | 0                | 2 (100)        | 0.1     |
| IAA + LVOTO, n (%)     | 2 (100)           | 0                | 0              | 0.5     |
| PAIVS, n (%)           | 1 (100)           | 0                | 0              | 0.5     |
| Mortality              |                   |                  |                |         |
| Early mortality, n (%) | 7 (4.8)           | 4 (2.7)          | 4 (2.7)        | 0.8     |
| Late mortality, n (%)  | 2 (1.3)           | 0                | 3 (2.0)        | 0.1     |
| Follow-up              | 7.2 [2.4 months to 18 years] | 5.3 years [4–11] | 12.2 [2.5 months to 17 years] | 0.003  |

VSD: ventricular septal defect; PS/PA: pulmonary stenosis/pulmonary atresia; CAT: common arterial trunk; TOF: tetralogy of Fallot; TGA: transposition of the great arteries; DORV: double outlet right ventricle; AS/AI: aortic stenosis/aortic insufficiency; AVSD: atrioventricular septal defect; IAA: interrupted aortic arch; LVOTO: left ventricular outflow tract obstruction; PAIVS: pulmonary atresia with intact ventricular septum.

Table 2: Operative data for 145 patients after the reconstruction of the right ventricular outflow tract

| Variable                  | Homograft, n = 62 | Contegra, n = 35 | Hancock, n = 48 | P-value |
|---------------------------|-------------------|------------------|----------------|---------|
| Conduit size (mm)         | 14 [8 to 16]      | 12 [12 to 16]    | 12 [12 to 14]  | 0.2     |
| z-score                   | 1.7 [-0.5 to 4.2] | 2.3 [-1.5 to 4.3]| 1.8 [0.25 to 4.06] | 0.5     |
| Orthotopic position, n (%)| 33 (40.2)         | 23 (28.0)        | 26 (31.7)      | 0.6     |
| Heterotopic position, n (%)| 29 (46.0)       | 12 (19.0)        | 22 (34.9)      | 0.6     |
| Extracorporeal cardiopulmonary circuit (min) | 129 [47 to 262] | 118 [41 to 361]  | 120 [40 to 260] | 0.6     |
| Aortic clamping time (min)| 62 [0 to 150]    | 85 [0 to 210]    | 60 [0 to 123]  | 0.003   |
| z-score before conduit exchange | -1.3 [-3.1 to 3.0] | 0.07 [-2.4 to 2.4] | -1.0 [-3.2 to 1.4] | 0.3     |

Comparison of the homograft, Contegra conduit and Hancock conduit.
and 64.8 ± 14.1, 44.2 ± 13.7, 52.1 ± 14.2% at 10 years, for homografts, Contegra and Hancock conduits, respectively. Patients with a Contegra conduit developed a moderate conduit insufficiency and stenosis faster than patients with homografts ($P = 0.01$, Figs 2 and 3).

A balloon valvuloplasty was required in 3 patients with a moderate stenosis, 2 with a Contegra conduit and 1 with a homograft.

A total of 72 patients (55%) required a conduit exchange at a median time of 5.9 years [1.1–10.8]. The rate of freedom from conduit exchange at 5 years was 69.4 ± 6.6, 59.4 ± 8.7 and 53.8 ± 7.4% for homografts, Contegra and Hancock conduits, respectively. The rate of freedom from conduit exchange at 10 years was 38.1 ± 8.3, 38.0 ± 11.3 and 20.3 ± 7.5% for homografts, Contegra and Hancock conduits, respectively. There was no difference in durability between the conduits ($P = 0.4$, Fig. 4). Within homograft conduits, there was no difference in durability between aortic, pulmonary and bicuspidalized homografts.

The reason for conduit exchange was a valvular stenosis in 39% patients ($n = 51$) at a median time of 4.2 years [4.3 months to 12 years], 21 (41%) with a homograft, 11 (21%) with a Contegra conduit and 19 (37%) with a Hancock conduit. Additionally, a distal stenosis was present in 6 patients, 4 with a Contegra conduit and 2 with a homograft. Conduit insufficiency was the reason for a conduit exchange in 14 patients (11%) at a median time of 3.4 years [11 days to 7 years], 6 (43%) with a homograft, 5 (36%) with a Contegra conduit and 3 (21%) with a Hancock conduit. Neither a proximal stenosis nor a conduit dilatation was found in any conduit. Endocarditis was the reason for conduit exchange in 1 homograft and 1 Contegra conduit at a median time of 5.3 years [3–8]. A thrombosis was present in 4 patients and led to a conduit exchange at a median time of 1.3 years [4 months to 6 years]. The Hancock conduit was the only conduit associated with a thrombosis ($P = 0.01$).

There were no differences between groups, regarding the right ventricular pressure and the ratio between the right and the left ventricular pressures before conduit exchange. Angiographic data before conduit exchange are depicted in Table 3.

At the time of conduit exchange, the conduits had a mean $z$-score of $-0.78 ± 1.4$. Neonates had a mean $z$-score of $-0.2 ± 1.8$, whereas patients over 1 month of age had a mean $z$-score of $-0.8 ± 1.4$ ($P = 0.4$).

### Risk factors

In the univariate Cox regression analysis, the heterotopic implantation of the conduits ($P = 0.02$) and an age below 1 month...
(P = 0.05) were identified as risk factors for conduit exchange. In the multivariate analysis, the heterotopic position of the conduit remained the only independent risk factor for conduit exchange (P = 0.02). Neither the conduit type, nor the conduit size had a significant influence on conduit durability (Table 4).

**DISCUSSION**

Since valved conduits are needed for surgery in congenital heart disease, the search for an ideal conduit is ongoing. Studies comparing different conduits are available [6, 8], but the results are diverging. It has been demonstrated that small-sized conduits exhibit a worse durability than larger ones [7, 13, 14]. However, there are no long-term data for the specific subgroup of neonates and infants available.

Hence, the aim of our study was to analyse the performance of different conduits in this specific group of patients and to analyse potential influencing risk factors for conduit durability. We found no difference in freedom from conduit exchange for homografts, Contegra and Hancock conduits. Overall conduit exchange was required at a median time of nearly 6 years, which is congruent with other reports [15].

One well-known reason for conduit failure is stenosis due to calcification or extensive intimal proliferation. In neonates and small infants, earlier conduit exchange may also be required due to somatic outgrowth [1, 8]. In our study, the reasons for conduit failure were diverging and the only significant difference between specific conduits was a higher rate of thrombosis in patients with a Hancock conduit. This could be due to the higher thrombogenic properties of the Dacron material and should be resolved by adequate anticoagulation. Because of the problem of early somatic outgrowth of conduits in young infants, some authors recommend the placement of larger conduits in these patients [16]. However, we found a mean z-score of –0.78 in patients requiring a conduit exchange, which shows that there was not a large discrepancy in size. Furthermore, there was no difference in z-scores prior to conduit exchange in patients below 1 month of age and older patients. In a study by Wells et al. [17], only 8% of 40 patients exhibited a somatic outgrowth of the conduit and, therefore, this was not seen as the main reason for conduit exchange. Karamlou et al. [15] reviewed patients with oversized conduits and found no advantage in the durability of oversized conduits in young patients. Hörer et al. [18] demonstrated that the annual increase in pressure gradient in homografts cannot be influenced by larger graft size.

In this study, the only independent risk factor for conduit failure is the heterotopic position of the conduit, which refers to patients undergoing a Rastelli operation or a correction of a CAT. Brown et al. [14] found that patients with a CAT were at a higher risk of developing conduit dysfunction. Hörer et al. [18] reviewed 116 patients after the Ross operation from the Dutch-German Ross Registry database and reported a rate of freedom from reoperation or reintervention on the homografts of 91.0 ± 2.9% at 5 years and 80.6 ± 6.5% at 10 years. Compared with our results, these encouraging findings of conduit longevity could be due to the orthotopic position of the conduit in Ross patients. This consideration was picked up by other authors [19]. It is not obvious why the heterotopic position is associated with worse durability of conduits.

Looking at the endpoint ‘first description of moderate stenosis or insufficiency’ on echocardiography, Contegra conduits are prone to an earlier degeneration in comparison with homografts. Although this result is not upheld with the endpoint ‘conduit exchange’, it remains a fact, which could cause right ventricular dysfunction in the long term.

**CONCLUSION**

In conclusion, the durability of homografts, Contegra and Hancock conduits are comparable, although there is a significantly faster development of stenosis and insufficiency in Contegra conduits when specifically compared with homografts. Age below 1 month remained the only independent risk factor for conduit exchange. In angiographic data for 72 patients before the conduit exchange:

| Variable          | Univariate analysis | Multivariate analysis |
|-------------------|---------------------|-----------------------|
|                   | HR  | 95% CI | P-value | HR  | 95% CI | P-value |
| Heterotopic position | 1.65 | 1.04–2.68 | 0.02 | 1.69 | 1.06–2.70 | 0.02 |
| Age below 1 month | 2.0  | 0.9–4.3  | 0.05 | 1.89 | 1.06–5.33 | 0.06 |
| Conduit type      | 1.19 | 0.91–1.56 | 0.18 |       |        |        |
| Conduit size      | 0.92 | 0.78–1.08 | 0.32 |       |        |        |
| z-score           | 0.88 | 0.70–1.10 | 0.28 |       |        |        |
| ECC time (min)    | 1.0  | 0.99–1.0 | 0.5 |       |        |        |
| Aortic clamping time (min) | 1.0 | 0.99–1.0 | 0.8 |       |        |        |
| z-score before conduit exchange | 5.7 | 3.42–9.40 | 0.19 |       |        |        |
| RV/LV ratio       | 1.0  | 0.98–1.01 | 0.2 |       |        |        |

ECC: extracorporeal cardiopulmonary circuit; RV: right ventricle; LV: left ventricle; HR: hazard ratio; CI: confidence interval.
Conflict of interest: none declared.

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APPENDIX: CONFERENCE DISCUSSION

Dr M. Huebler (Zurich, Switzerland): I have three questions. First, I couldn’t find the exact indication for the reoperation, so what was the gradient for the indication of reoperation? Second, is there any rationale for using a specific type of conduit in a specific subset of patients with reference to neonatal patients or patients with an increased pulmonary vascular resistance? Lastly, in your manuscript you described four patients in the Hancock group with thrombosis of the Hancock conduit: what is the general medical treatment after implantation of the conduit?

Dr Vitanova: Regarding your question on the use of conduits, we always prefer homografts. But if homografts are not available, we use Contegra conduits. We prefer Contegra because the Hancock conduits are known for their rigidity due to Dacron. And for small children, especially the children requiring the Ross operation, we do not use a Hancock conduit because we find it very difficult in the surgical technique to sew the proximal anastomosis without compromising the coronary ostia. We always exchanged the conduits when we diagnosed a moderate stenosis or a moderate insufficiency, or when there was endocarditis or thrombosis present. Regarding the first two, moderate stenosis or insufficiency, the diagnosis was made only by echo, and when the right ventricular function was well preserved in the patients, we did not change the conduit. So we took a look at the gradient, and normally we exchange the conduit at a gradient between 40 and 50 mmHg and with moderate dysfunction of the right ventricle. And yes, we had four patients, all with Hanscocks, who were exchanged because they had thrombosis. Based on our data, we now use aspirin therapy after Hancock implantation.

Dr L. Galletti (Bergamo, Italy): I have a quick question. What is the role of interventional catheterization in your institution? In our institution before surgeons change a conduit for any reason, a cardiologist at least tries to place a stent inside.

Dr Vitanova: Yes, most patients had a catheterization, especially when our echo result was unclear or when we were not sure of the results according to the stage of stenosis or insufficiency.

Dr S. Mohanty (Mumbai, India): I have a quick comment. We do not have access to homografts as you people have. Do you have any experience with the technique of reconstructing a conduit out of pericardium? We have been using that for a while. It’s working pretty well, especially for these small kids. Totally autologous pericardium, reconstructing the valve cusp and implanting it.

Dr Vitanova: Do you mean reconstructing the implanted conduit?

Dr Mohanty: No. It’s constructed from the patient’s pericardium. Do you have any experience with that? I think that’s a fantastic thing for the smaller neonates and infants.

Dr Vitanova: No, we don’t use this technique.

Dr Z. Al-Halees (Riyadh, Saudi Arabia): We have used pericardial conduits with and without a valve, but we found the incidence of calcification very high, so we stopped using it. I think the largest experience comes from the Argentina group (J Thorac Cardiovasc Surg 2000;119:869–79). They reported no stenosis, but there is a high incidence of pulmonary regurgitation developing within six months of implantation. So you’re exchanging the stenosis for regurgitation.

Dr H. Najm (Riyadh, Saudi Arabia): Your numbers are quite low to draw any very strong conclusions from them. We’ve used the Contegra for close to 200 implants now for the past 12 or so years and what we found is that the most predictable reason for them to come back is actually distal anastomotic stenosis, and in particular for those patients who are below one month of age. And, as we all know, the smallest Contegra is 12 mm, and they’re actually bigger than 12 mm when you look at your data specifically for those young patients and correlated the size of the conduit implanted initially compared to the incidence of reoperations? Also whether the choice of valve relates to the outcome. Obviously, you’ve got three types here, and I am sure there is a lot of selection bias as you’ve indicated before relating to the availability of the conduit rather than the actual morphology or the suitability of that particular conduit for that particular patient.

Dr Vitanova: Yes, we compared the different sizes, especially with Contegra, because we also had a distal stenosis with the Hancock conduits and with Contegra conduits, but they were all associated with valve stenosis or insufficiency. There was no difference between the conduit diameter according to the valve and the factor influencing a stenosis.

Dr Najm: We have shied away from putting size 12 Contegras in babies less than 3 kg because they’ve got small PAs and there are shear forces at the end that trigger the stenosis.