Experience and intermediate-term results using the Contegra \textsuperscript{\textcopyright} heterograft for right ventricular outflow reconstruction in adults\textsuperscript{*}

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Abstract

Objective: The Contegra\textsuperscript{\textcopyright} bioprosthesis (valved heterologous bovine jugular vein) is used for reconstruction of the right ventricular outflow tract (RVOT) in congenital heart malformations and pulmonary valve replacement in different settings. Compared to pulmonary homografts, the Contegra\textsuperscript{\textcopyright} conduit is readily available 'on the shelf'. So far, its use was mainly described in children. The aim of this study is to evaluate the feasibility and the outcome of Contegra\textsuperscript{\textcopyright} graft implantation in the adult. Methods: Between November 1999 and December 2007, a total of 32 Contegra\textsuperscript{\textcopyright} grafts were implanted in 31 patients (24 men and 7 women), with a mean age of 35.7±10.5 years (range 18–54 years). All operations have been completed through median sternotomy with cardiopulmonary bypass. Indications included: Ross procedure for aortic valve disease (n=22); re-operation of corrected Fallot-tetralogy (n=5); isolated pulmonary valve disease (n=2); re-operation of double outlet right ventricle (DORV) (n=1); pulmonary stenosis in congenital dilated cardiomyopathy (DCM) (n=1). Conduit sizes included 22 mm (n=31), 20 mm (n=1). Results: There was no hospital mortality and no valved conduit related early morbidity. In the median follow-up of 38 months (range 1–99 months) of 28 patients there was one late death, not conduit related (total mortality 3.6%). Re-operation for symptomatic graft stenosis was realised in two patients, 7 and 16 months after primo-implantation, corresponding to graft related late morbidity of 7.1%. Conclusions: In this small review of 32 operations using the Contegra\textsuperscript{\textcopyright} graft for RVOT reconstruction in adult cardiac surgery for different indications, we observed good postoperative mid-term results concerning conduit function. Mean transpulmonary pressure gradients remain low (13.3±6.6 mmHg postoperative, 14.5±7.9 mmHg at follow-up). The use of the Contegra\textsuperscript{\textcopyright} graft seems to be a good alternative to the homograft with low operative mortality and morbidity. Long-term outcome data are not available and further investigations must be performed to evaluate results.

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Keywords: Contegra\textsuperscript{\textcopyright}; RVOT reconstruction; Ross procedure; Adults; Fallot-tetralogy; Pulmonary stenosis

1. Introduction

Implantation of a valved conduit is a common procedure for the reconstruction of the right ventricular outflow tract (RVOT) in congenital heart malformations or for pulmonary valve replacement in a Ross procedure. Research focuses on finding ‘optimal’ conduits. Since its introduction in 1999 the Contegra\textsuperscript{\textcopyright} bioprosthesis (initially marketed under the name VenPro\textsuperscript{\textcopyright}), consisting of a bovine jugular vein with a tri-leaflet venous valve, has been widely accepted as a possibility to perform RVOT reconstruction in children with encouraging postoperative mid-term results at follow-up [1–3].

Less common is its use in adult cardiac surgery as an alternative conduit to homograft application. Our experiences and mid-term results of Contegra\textsuperscript{\textcopyright} graft implantation in 31 adults will be discussed.

2. Materials and methods

2.1. Patients

From November 1999 to December 2007, 32 Contegra\textsuperscript{\textcopyright} graft implantations in 31 patients have been realised (24 men, 7 women). Median age at surgery was 35.7±10.5 years (range 18–54 years), median weight was 67.8±16.2 kg (range 44–97.5 kg).

2.2. Conduit sizes

A 22-mm conduit was implanted in 30 patients; a 20-mm conduit was used in one patient.

2.3. Indications

Indications included isolated aortic valve disease in 22 patients leading to a Ross procedure, recurrent pulmonary stenosis in a precedent operated Tetralogy of Fallot in five patients and double outlet right ventricle (DORV) in one patient. Two patients presented isolated pulmonary valve insufficiency. In another patient, the Contegra\textsuperscript{\textcopyright} conduit

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was implanted for symptomatic pulmonary stenosis in the context of congenital dilated cardiomyopathy (DCM) (Table 1).

2.4. Previous surgery

Previous surgical corrective interventions were performed in all patients of the Tetralogy of Fallot group. Also the patient presenting the DORV had palliative shunting, at seven years of age (Table 1).

2.5. Operative procedures

All operations were conducted through median sternotomy with cardiopulmonary bypass. Mean cardiopulmonary bypass time was 155 ± 59 min (range 38–233 min) and mean aortic cross-clamping time was 86 ± 26 min (range 7–128 min).

In the Ross group, an additional ‘reduction ascending aortoplasty’ using a Mersilene-mesh for dilatation of the ascending aorta was realised in five patients and another patient underwent venous aortocoronary bypass to the right coronary artery for significant stenosis.

2.6. Anti-platelet therapy

All patients underwent postoperative anti-platelet therapy for at least three months.

2.7. Early follow-up

Transthoracic echocardiography was performed in all patients one week after surgery, measuring mean transpulmonary pressure gradients and calculating left ventricular ejection fraction (EF) before leaving the hospital.

2.8. Mid-term follow-up

Follow-up data were obtained in April 2008, corresponding to mid-term follow-up time of 38 months (range 1–99 months). Echocardiography control was performed by the attending cardiologists. Mean transpulmonary pressure gradients were compared to the results at one week follow-up. Three patients have been lost to follow-up, corresponding to mid-term follow-up rate at 90%.

2.9. Statistical analysis

Data are expressed as mean ± S.D. and ranges where appropriate. Survival and freedom from re-operation were analysed according to Kaplan–Meier estimates.

3. Results

3.1. Immediate postoperative

There was no hospital mortality following surgery and no direct valved conduit related early morbidity.

Three patients underwent re-operation for exploration and haemostasis for cardiac tamponnade, 5 h, 10 h and 3 days after initial surgery. In one case, an open heart massage and aortic coronary venous bypass for gas embolus, causing ventricular fibrillation was realised in the immediate postoperative period.

One patient developed significant insufficiency of the aortic neo-valve rapidly after Ross procedure, requiring a Bentall operation using a mechanical aortic valve prosthesis two weeks later. Echocardiography at 54 months postoperative showed excellent results of the pulmonary heterograft.

3.2. Echocardiography at one week

All patients had trans-thoracic echo before leaving hospital with a mean pulmonary pressure gradient of 13.3 ± 6.6 mmHg (Ross procedure n = 22: 12.9 ± 5.3 mmHg, Tetralogy of Fallot n = 5: 12.2 ± 2.8 mmHg, isolated pulmonary valve disease n = 2: 6 ± 0 mmHg, DCM: 21 mmHg, DORV: 35 mmHg), no patient had significant valvular insufficiency (Fig. 1).

3.3. Mid-term follow-up

There was one late death 39 months after surgery. The patient suffering from congenital DCM died, in consequence of chronic heart failure, not conduit related (total mortality: 3.6%).

Last echo of this patient at 39 months follow-up showed low transpulmonary gradient, probably underestimated because of decreased cardiac function (EF of 30%). All

Table 1

<table>
<thead>
<tr>
<th>Group</th>
<th>Patients (n=31)</th>
<th>Etiology</th>
<th>Operative procedure</th>
<th>Previous surgery (n=10)</th>
<th>Mean age (35.7 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>22</td>
<td>Isolated aortic valve disease</td>
<td>Ross procedure</td>
<td>1 Correction of aortic coarctation</td>
<td>37 years</td>
</tr>
<tr>
<td>II</td>
<td>5</td>
<td>Tetralogy of Fallot: 2 PV stenosis</td>
<td>Pulmonary valve replacement after previous correction of Tetralogy of Fallot</td>
<td>5 Closures of interventricular communications: + 3 RVOT enlargements by trans-annular patch + 1 previous Blalock-Taussig-Shunt + 1 PV replacement by homograft</td>
<td>26.4 years</td>
</tr>
<tr>
<td>III</td>
<td>2</td>
<td>Isolated pulmonary valve disease</td>
<td>Pulmonary valve replacement</td>
<td>1 PV commissurotomy + closure of patent foramen ovale</td>
<td>36.5 years</td>
</tr>
<tr>
<td>IV</td>
<td>1</td>
<td>DORV</td>
<td>Complete correction</td>
<td>1 Aorto-pulmonary central prosthetic shunt</td>
<td>30 years</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Congenital DCM</td>
<td>Pulmonary valve replacement</td>
<td>1 PV commissurotomy + closure of patent foramen ovale</td>
<td>54 years</td>
</tr>
</tbody>
</table>

RVOT, right ventricular outflow tract; DORV, double outlet right ventricle; DCM, dilated cardiomyopathy.
other patients had a normal cardiac function (EF \geq 55\%) at mid-term follow-up.

Two patients of the Ross group underwent re-operation for symptomatic graft stenosis (total graft related late morbidity: 7.1\%). Replacement of the Contegra\textsuperscript{5} graft was realised 7 and 16 months after primo-operation.

- One patient presented a conduit stenosis after postoperative mediastinitis three months after surgery. Re-operation at seven months was done using a homograft.
- The second patient was re-operated for symptomatic graft stenosis, due to insufficient diameter of both, proximal and distal conduit anastomosis, after 16 months. The Contegra\textsuperscript{5} graft showed soft and functional valve leaflets without calcifications and re-operation, using a new Contegra\textsuperscript{5} conduit, was completed by enlargement with trans-anastomotic patch implantation with satisfying results at follow-up.

Kaplan–Meier estimation shows cumulative survival of 0.93 \pm 0.34 and cumulative re-operation free survival rate of 0.91 \pm 0.39 at nine years (Fig. 2).

3.4. Echocardiography at 38 months mean follow-up (follow-up rate: 90\%)

Mean pulmonary pressure gradient was 14.5 \pm 7.9 mmHg (Ross procedure \(n=19\): 14.1 \pm 8.8 mmHg, Tetralogy of Fallot \(n=5\): 15.8 \pm 6 mmHg, isolated pulmonary valve disease \(n=2\): 12.5 \pm 3.5 mmHg, DCM: 10 mmHg\textsuperscript{1}, DORV: 24 mmHg).

No patient had significant pulmonary insufficiency, trace or mild grade insufficiency remained stable in comparison to early echo control (Fig. 3).

Analysis of follow-up time in relation to mean transpulmonary pressure gradients distribution showed an independence of both parameters. Conduit stenosis due to eventual progressive calcification seems to be independent from follow-up time (Fig. 4).

4. Discussion

In the recent decade, the implantation of the valved heterologous bovine jugular vein, the ‘Contegra\textsuperscript{5} bio-prosthesis’ for RVOT replacement, as part of surgical treatment in the Ross procedure, as well as in complex congenital heart malformations has been widely accepted. Encouraging mid-term results for the Contegra\textsuperscript{5} implantation in children are available and have been reported [1–4]. Previous published studies did not show a ‘relevant average valvular gradient development’ in mid-term follow-up of the graft [3]. By this way, the Contegra\textsuperscript{5} conduit became a satisfying alternative to homografts in paediatric cardiac surgery [3, 5]. Main advantages using the Contegra\textsuperscript{5} in RVOT reconstruction are the availability in different diameters, sufficient lengths of tissue proximal and distal to the venous valve and moderate costs.

\textsuperscript{1} Low transpulmonary pressure gradient because of increased cardiac function (EF of 30\%).
In cases of aortic valve disease requiring surgery in infants and children, the Ross procedure is today the operation of choice. Main advantages of this therapeutic option are the use of the patients' own valves with favourable hemodynamic characteristics, low risk of endocarditis, avoidance of anticoagulant therapy, low thrombogenicity and the potential of growth of the auto-graft [3]. The last point is non-relevant in young, full-grown adults. Contraindications for oral anticoagulation and child-bearing potential in women could lead the surgeon, together with the patient, to go for a Ross procedure. Recent series of the Ross procedure including adult patients showed good postoperative results with low mortality [6–9]. RSA reconstruction is usually accomplished using either cryopreserved or demineralised homografts. In the published series pulmonary stenosis or insufficiency due to the homograft calcification, requiring re-operation with replacement of the homograft was low (2.6%–3.6%) [6, 7, 9, 10]. On the other hand, disadvantages correspond to the above-mentioned missing availability in different diameters and sufficient length and high costs of the pulmonary homograft. Looking for alternatives to realise RSA reconstruction is in the interest of increased research.

Comparative follow-up, in the era before the Contegra® graft, of alograft vs. xenograft implantation for RSA reconstruction, showed equal results concerning survival, but significant better long-term durability of alografts. However, implanted biological valves (Hancock®) consisted of porcine valvular leaflets fixed on a stent and most of the patients were children with only a few adults in this series [11].

Few results are available using the valved bovine jugular vein in adult cardiac surgery. For this reason, an isolated analysis of Contegra® graft implantation in these settings seems to be mandatory.

In this report, we describe our experience with 32 operations, in 31 adult patients with bovine jugular vein conduits implanted. Main indications are the Ross procedure, late re-operation of a corrected Tetralogy of Fallot, followed by isolated pulmonary valve disease, with satisfactory early postoperative and mid-term follow-up results in this group. All these patients had normal cardiac function, two patients of the Ross group developed conduit stenosis (Fig. 3). The first developed pulmonary stenosis immediately post endocarditis (mean transpulmonary pressure gradient of 40 mmHg at seven months after surgery). Progressive asymptomatic light pulmonary stenosis could be observed at nine years follow-up in one other patient (mean transpulmonary pressure gradient of 26 mmHg), probably due to progressive conduit calcification and degeneration, corresponding to a spontaneous calcification rate leading to pulmonary stenosis of 3.6%. However, not statistically relevant because of the small series, this value probably indicates equal outcome using the bovine jugular valved vein as pulmonary homograft implantation with the above-mentioned advantages for the Contegra® conduit.

Main argument for previous cited authors [9, 11] using systematically pulmonary homograft for RSA reconstruction for a Ross procedure in adult cardiac surgery is the better long-term outcome in comparison to other valved conduits. These included all sorts of conduits, also artificial ones, but an isolated or comparative analysis of the outcome after implantation of the bovine jugular valved vein in adults is not available.

Results of our series indicate that conduit stenosis due to eventual progressive calcification seems to be independent from follow-up time. Excellent postoperative results in six years follow-up front less good results with slightly elevated mean transpulmonary pressure gradients at one or two years follow-up (Fig. 4). Prognostic of postoperative function of the Contegra® graft at long-term seems to correlate to initial early postoperative results. There was poor shifting between different groups concerning pulmonary gradients at early and mid-term follow-up.

Re-operation in two patients for conduit stenosis was needed after a short follow-up time of 7 and 16 months corresponding to a re-operation rate of 7.1%. Both cases were due to particular circumstances. Rapid conduit degeneration post fulminant endocarditis in the first and an intact, smooth conduit creating stenosis due to mismatch at the anastomotic junctions of the graft implantation sites in the second case.

By way of conclusion, it should be pointed out that the Contegra® graft seems to be a good alternative to the homograft in adult cardiac surgery, with low operative mortality and morbidity. Kaplan–Meier analysis showed a cumulative survival of 0.93 ± 0.34 at nine years, with one death not conduit related. Cumulative re-operation free survival rate was 0.91 ± 0.39 at nine years.

In the mid-term follow-up of 38 months mortality was kept low (one death not conduit related), with good results of the functioning of the Contegra® graft at early and mid-term echocardiography follow-up. To work out mid-term results using a Contegra® graft for other indications than the Ross procedure are limited, because of the small number of patients. However, excellent results for isolated pulmonary valve replacement in two young and otherwise cardiac healthy patients, acceptable results in the Fallot group, inferior outcomes in the complex congenital cardiac malformation and the late death in the case of DCM argues for an etiologic correlation.

Low transpulmonary pressure gradients, even at follow-up >5 years, argues against progressive systematic conduit calcification, creating significant pulmonary stenosis at long-term follow-up.

Finally, using a Contegra® for pulmonary valve replacement in adults seems to be a good option. We found good hemodynamic results and freedom from calcification in mid-term follow-up. The maximal on-hand conduit diameter of 22 mm is an adequate size in adults. Long-term outcome data are not available and further investigations must be performed to receive valuable results.

References


