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Early Results of Using the Bovine Jugular Vein for Right Ventricular Outflow Reconstruction during the Ross Procedure

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ABSTRACT

Objective: To study the early function of the bovine jugular vein (BJV) when used for right ventricular outflow tract (RVOT) reconstruction during the Ross procedure.

Methods: Seventeen consecutive patients (median age, 12 years; range, 30 days to 40 years) who had undergone a Ross procedure with RVOT reconstruction using a BJV were reviewed. Nine patients had prior balloon valvotomy (n = 6) and/or surgical aortic valvotomy (n = 4). Additional procedures included a reduction-plasty of the ascending aorta (5 patients), a Konno procedure (2 patients), a mitral valve repair/replacement (2 patients), and others (3 patients). The size of the BJV ranged from 12 to 22 mm (median, 20 mm).

Results: There were no early or late deaths. None of the patients encountered any significant postoperative complications. The neo-aortic valve showed good function in all patients with no more than trivial insufficiency. At a median follow-up period of 11 months, the frequency of freedom from BJV graft dysfunction/reintervention/reoperation was 100%. One patient had moderate insufficiency of the BJV in a perioperative examination that regressed to mild insufficiency during follow-up. Overall, none of the patients had more than mild insufficiency at follow-up. Four patients showed a flow acceleration of more than 250 cm/s (equivalent to a gradient of 25 mm Hg) across the BJV, and the remaining patients had lower gradients.

Conclusions: The BJV, when used to replace the pulmonary valve in the Ross procedure, showed excellent function in the early phase. The large size range and easy availability of this valved conduit are particularly attractive. Further follow-up is needed to determine the long-term results of its use.

INTRODUCTION

The use of a pulmonary autograft to replace a diseased aortic valve (the Ross procedure) has become the procedure of choice for correcting congenital aortic stenosis, not only because of the procedure's excellent performance in both the short and long terms, but also because of the limitations of the mechanical and biological valves available for replacing the native aortic valve in pediatric patients [Kouchoukos 1994, Elkins 2001].

In spite of being technically demanding, the Ross procedure has been widely accepted because of its obvious advantages of having a living autogenous valve in the aortic position—excellent hemodynamics, a potential for self-repair and growth, and no need for anticoagulation therapy [Elkins 2001].

Although the debate on the long-term durability as well as the growth potential of the autograft is gradually concluding, the concern about the durability of conduits used for RVOT reconstruction continues to preclude the extended use of this procedure [Oury 1998]. Homografts are known to be prone to early calcific degeneration, especially in pediatric patients with a high calcium metabolism [Yankah 1995]. Tissue-engineered autogenous valved conduits, long touted as ideal, have yet to instill substantial confidence [Simon 2003]. It is in this context that we started to implant grafts of the bovine jugular vein (BJV) for right ventricular outflow tract (RVOT) reconstructions. Here, we describe our early results of 17 BJV implantations during the Ross procedure out of a total of 68 implantations performed at our clinic from May 2001 to January 2003.

MATERIALS AND METHODS

Cases were reviewed for 17 consecutive patients (median age, 12 years; range, 30 days to 40 years) who had undergone operations between January 2002 and January 2003 with a Ross procedure using RVOT reconstruction and a BJV (Figure 1). There were 13 male and 4 female patients. Indications for the Ross procedure were congenital aortic valve disease (13 patients), aortic valve endocarditis (3 patients), and severe aortic insufficiency associated with a ventricular septal defect (1 patient). Nine patients had undergone prior balloon valvotomy (6 patients) and/or surgical aortic valvotomy (4 patients).

A pulmonary autograft was implanted as a root replacement with continuous polydioxanone sutures. Right ventricle–pulmonary artery continuity was reestablished with a Contegra graft (Medtronic, Minneapolis, MN, USA). The distal anastomosis was performed first, followed by the proximal anastomosis, to maintain a short, straight course of the graft (Figure 2). Contegra anastomoses were performed with continuous polypropylene sutures during the rewarming phase of cardiopulmonary bypass. Additional procedures performed were the Konno procedure for the enlargement of the septum

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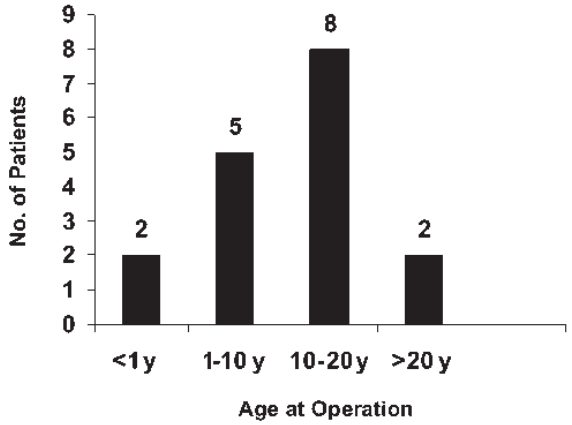

Figure 1. Age distribution of patients.

(2 patients), mitral valve repair/replacement (2 patients), reduction-plasty of the ascending aorta (5 patients), ventricularseptal defect closure (1 patient), and others (2 patients). The size of the BJV implanted ranged from 12 to 22 mm (median, 20 mm). The median cross-clamp and bypass times were 129 minutes (mean, 143 ± 44 minutes) and 230 minutes (mean, 249.8 ± 66.6 minutes), respectively. Patients were followed up with periodic echocardiography examinations. Between 3 months and 6 months postoperatively, all patients underwent coronary angiography as a part of a prospective study.

RESULTS

There were no early or late deaths. The only patient who needed postoperative surgical revision had a periautograft hematoma early in the postoperative period that required evacuation. The neo-aortic valve showed excellent function in all of the patients with no more than trivial central insufficiency in a few patients. This finding remained stable in the subsequent echocardiographic follow-up examinations. One patient showed an asymptomatic 50% stenosis of the proximal right coronary artery at the 3-month angiographic examination, and the artery was successfully dilated and stented.

BJV Function

At a mean follow-up period of 11 months, the frequency of freedom from BJV reintervention/reoperation or dysfunction was 100%. One neonate with a borderline hypoplastic left ventricle associated with congenital aortic stenosis showed moderate insufficiency of the BJV (consequent to severe pulmonary hypertension) during a perioperative examination, and this insufficiency regressed to mild during the follow-up period. Overall, no patient had more than mild insufficiency at the last follow-up examination. Four patients showed a Doppler-measured flow acceleration of more than 250 cm/sec across the BJV (mean, 270 cm/sec) with no morphologic obstruction, and this acceleration was handled conservatively (Figure 3).

DISCUSSION

From the time Donald Ross first described this procedure of pulmonary autograft implantation for managing congenital aortic stenosis [Ross 1967], it has had its share of controversies. Proponents have described it as being the nearest to an ideal solution to the problem, whereas critics have described it as a procedure that involves converting an aortic valve pathology into an aortic-plus-pulmonary valve disease. The criticism essentially had to do with concerns of finding a suitable conduit for reconstructing the RVOT following the harvest of the pulmonary autograft.

Various conduits have been used for reestablishing right ventricle–pulmonary artery continuity following explantation of the pulmonary autograft. Valved homografts, and pulmonary homografts in particular, have been the most popular conduits because of their better long-term results [Yankah 1995]. However, for various known reasons, there has been an

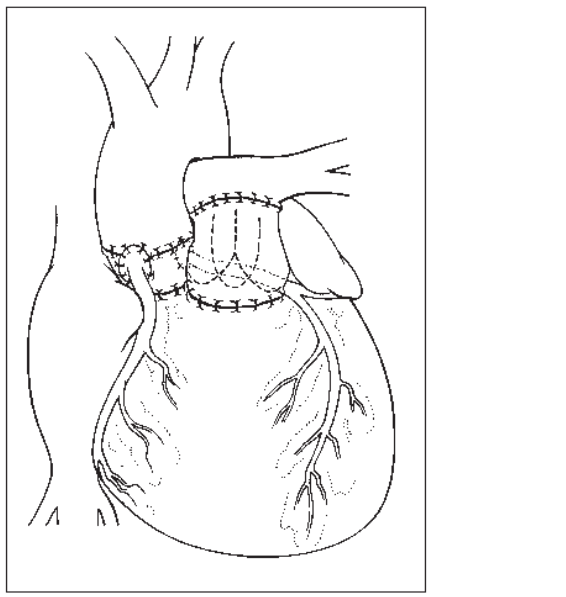

Figure 2. Schematic diagram of the use of the bovine jugular vein for right ventricular outflow tract reconstruction during the Ross procedure.

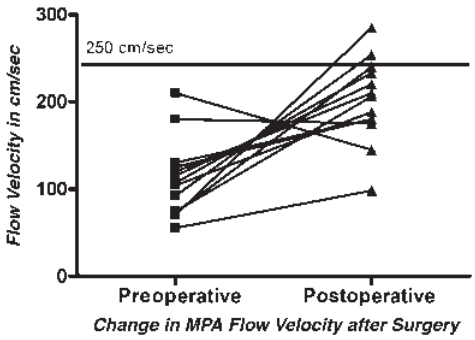

Figure 3. Change in Doppler flow velocity in the main pulmonary artery (MPA) following bovine jugular vein implantation.

increasing gap between the demand for and the supply of homografts, especially in the smaller size ranges meant for neonates and infants. The scarcity of homografts also has meant that it is not possible to have a wide range of sizes available in the operating room to choose from, and, as with all nonliving conduits, the homografts are susceptible to progressive structural degeneration and outgrowth, especially in young patients [Yankah 1995]. Two of our patients (aged 30 days and 38 days) needed a Ross procedure on a semiemergent basis, and, in our opinion, finding a correctly sized homograft on short notice in these cases would have been extremely unlikely.

Using BJVs to reconstruct the RVOT appeared to address some of these logistical problems [Bove 2002]. Animal studies using BJV in dogs showed excellent function for these conduits [Ichikawa 1997]. Therefore, we started using these conduits for various congenital cardiac reconstructions and performed BJV implantations as a part of the Ross procedure in 17 patients between January 2002 and January 2003 (Figure 2).

As other research groups have noted, the BJV has excellent handling characteristics, and the centrally placed inherent tricuspid valve makes fashioning of the proximal hood easy. Having a wide range of sizes available off the shelf allows the luxury of selecting the conduit size after seeing the pulmonary artery intraoperatively. We have not observed any evidence of coronary compression due to the conduit, thanks to its supple wall.

The conduit and the valve have showed satisfactory postoperative function. None of the grafts showed more than mild insufficiency in the early postoperative period, and the insufficiency does not seem to be progressive. It appears that the relationship between the height and the diameter of the valve seems particularly favorable for good coaptation, thus maintaining the competence of the valve in spite of mild distortion.

The right ventricular outflow conduit demonstrated turbulence in Doppler flow studies in some patients, which is likely to be due in part to the inertia of the conduit wall. The flow velocities in the conduit were more than 250 cm/sec (mean, 270 cm/sec) in 4 of our patients, and there was no evidence of morphologic stenosis. These patients could be managed conservatively. These findings are in conformity with observations that the higher-than-normal gradients reported to develop across the RVOT during the use of different types of conduits could be managed nonsurgically [Kouchoukos 1994, Corno 2001]. However, a close watch on the behavior of BJV conduits in these patients over the medium and long terms is warranted to look for a progression of stenosis.

A 100% freedom from reintervention and conduit dysfunction at a mean follow-up period of 11 months in our series of BJV grafts is encouraging. To what extent these results can equal or improve upon the reported frequencies of freedom from RVOT reintervention for allografts remains to be seen [Albert 1993, Elkins 1998, Elkins 2001].

CONCLUSION

In conclusion, the use of the BJV to reestablish right ventricle–pulmonary artery continuity during the Ross procedure has shown excellent function in the early phase of follow-up. The large size range and easy availability of this valved conduit are particularly attractive. Longer follow-up periods are needed to compare the durability of this conduit with that of homografts.

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