Homograft saphenous vein versus polytetrafluoroethylene graft for modified Blalock -Taussig shunt

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Abstract

Back ground: **Modified Blalock-Taussig shunt is an important initial palliation in a selected subset of patients. This randomized controlled study was conducted to evaluate and compare PTFE and homograft saphenous vein as a conduit for this purpose.**

Patients and Methods: **Thirty patients were prospectively randomized to receive either a Polytetrafluoroethylene (PTFE) or an antibiotic preserved homograft saphenous vein as conduit. Early results were analysed and compared.**

Results: **Mean graft size was 3.93 mm±0.53 and 4.2 mm±0.53 in the PTFE and vein group respectively. There were 3 hospital deaths in the vein group and none in the PTFE group. There were 2 early and no late shunt thromboses in PTFE group while 1 early and 2 late thrombosis occurred in vein group. These differences were statistically insignificant. The incidence of post-operative bleeding, peri-graft seroma and operative time was less in vein then PTFE group. Palliation on follow-up was comparable in both groups.**

Conclusion: **This study failed to demonstrate any benefit of homograft saphenous vein over PTFE graft in terms of thrombotic complications and mortality. There was however less bleeding and peri-graft seroma formation in the Saphenous vein (SVG) group. Further studies with greater number of patients and longer follow-up are required to demonstrate the superiority of either of these conduits.** ***(Ind J Thorac Cardiovasc Surg 2008; 24: 227-232)***

Key words: Saphenous vein, Thrombosis, Congenital heart disease

Introduction

In spite of an increase in primary repair of most congenital cardiac anomalies, systemic-to pulmonary artery (PA) shunts are still the preferred initial palliation for a subset of patients with univentricular physiology and in certain other subset of patients where contraindications to an early primary repair exist. The Great Ormond Street modification[1] of the Classical Blalock- Taussig[2] shunt (BTS) using a synthetic polytertafluoroethylene (PTFE)[3] revolutionized the procedure with advantages of flexibility in size, avoidance of limb ischemia, ease of construction and takedown with good pulmonary artery growth and less distortion as compared to the classical Blalock-Taussig shunts[4]. Today, modified Blalock Taussig shunt has almost replaced other systemic to pulmonary shunts. There has been an increasing interest in using a homograft saphenous vein (SVG)[5-8] as an alternative to the PTFE graft. The claimed advantages of this substitute are ease of suturing, less needle hole bleeding, availability in all sizes, less incidence of peri-graft seroma formation and relative resistance to infection[5,8].

However, there is no prospective randomized trial comparing the use of homograft saphenous vein (SVG) with the PTFE graft for this purpose. The aim of this study was to evaluate and compare the early results with PTFE and SVG in similar group of patients.

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Material and Methods

The study population consisted of 30 consecutive patients undergoing systemic to pulmonary artery shunt at the All India Institute of Medical Sciences, New Delhi, India between July 2007 and December 2007. Institutional review board approval was obtained for the study and informed consent was taken from the parents of the patients after explaining to them the details about the purpose of the study.

Pre-operative Studies

All patients underwent echocardiography, and or Computed tomography (CT) angiography and cardiac catheterization and cineangiography as indicated. Pre-operative hemoglobin, saturation, PaO2, thoracic aorta diameter at level of diaphragm and branch pulmonary artery sizes were recorded. Exclusion criteria included emergency procedures in sick neonates. Patients of both groups were operated by same surgeons to eliminate the effect of operative skill on outcomes between two groups.

Homograft Vein preservation and Banking[9-11]

Extra segments of saphenous veins remaining at the end of coronary artery bypass grafting and those obtained from live brain-dead donors who are candidates for organ donation are used. Although we have the facility for cryopreservation of heart valves, we use antibiotic-preservation for homograft veins. After rinsing the veins with 500 ml cold saline to remove any blood, these veins are stored in sterile filtered nutrient tissue culture medium (Hank's solution). To every 1 liter of this solution, the following antibiotics are added: Cefoxitin 250 mg; lincomycin 120 mg; polymyxin B 100 mg; vancomycin 50 mg; and nystatin 1 million units. HEPES buffer is added to maintain pH between 6.6-7.0. 100 ml of sterile solution is added to each homograft for storage at 4°C. These antibiotic preserved homograft veins are used within 45 days. Prior to preservation the size of the distended vein was measured using a caliper and was recorded. Blood group of the donor was also recorded.

Blood was taken from the donors for serologic tests for hepatitis, human immunodeficiency virus, cytomegalovirus, and syphilis. If any of these tests were positive, the grafts were not used.

Operative technique

The modified Blalock Taussig shunt was performed using a standard postero-lateral thoracotomy through the fourth intercostal space. Just prior to the placement of the conduit, the circulating operating room nurse was asked to draw a chit which contained the choice of the graft: Thin PTFE (WL Gore, Elkton, MD, USA) or SVG from a box which contained 15 chits of either substitute. This ensured randomization. Using standard surgical techniques, the proximal and distal anastomoses of the conduit were constructed to the subclavian and pulmonary artery respectively. Heparin was not reversed at the end of the procedure.

Post-operative management and assessment

All patients were placed on full ventilator-support in the immediate post -operative period. Patients were kept nil per orally and were on intra venous fluid @ 4 ml/kg/hr initially. Rate of fluid infusion was adjusted later according to hemodynamics and urine output. All patients were on inotropic support to maintain systolic blood pressure more than 90 mm Hg. Heparin was started @ 10-15 units/kg/hr infusion and adjusted to keep activated clotting time more than 250 seconds. Post-operative SO_2 was recorded on pulse oximetry and complete arterial blood gases were obtained for all patients at regular intervals. Shunt murmur was auscultated on arrival in the intensive care unit and at periodic intervals. Amount of drainage from the chest tubes was recorded and serial chest radiographs were obtained for evidence of pleural collection and peri-graft seroma formation. Presence of peri-graft collection on radiographs and serous drainage from the chest tubes indicated a peri-graft seroma. Echocardiography was performed within 6 hours to document graft patency. Once hemodynamics were satisfactory with oxygen saturation more than 80% and graft patency documented, patients were weaned off ventilator. After extubation, Aspirin 5 mg/kg/day was started and heparin was stopped. In cases of early PTFE graft occlusion either thrombectomy or graft revision was performed as indicated. In cases of repeated homograft saphenous vein occlusion, it was replaced with a PTFE graft.

Hospital failures were defined as those occurring before hospital discharge and late failure were those occurring after discharge.

Follow-up

All hospital survivors were followed up at 3 monthly intervals. At each visit, SO_2 was measured, chest X- ray and echocardiography were performed for shunt patency, pulmonary artery growth and dilatation of the conduit in the SVG group. Arterial blood gas was done to measure PaO_2 in selected patients where cyanosis increased clinically or there was doubt on amount of flow on echocardiography.

Unsatisfactory palliation[12] was defined as (a) Complete occlusion (b) Re-appearance of cyanosis with progressive decrease of PaO_2 of 5 mm Hg or more (c) Progressive increase in Hemoglobin of 2 g or more (d) saturation drop by more than 10% (e) Need for second shunt or non elective repair.

Statistical Analysis

Data was analyzed with Biomedical Data Processing Statistical Software (University of California Press, Berkley, CA) and SPSS 10.0 statistical package (SPSS Inc., Chicago IL, USA).Continuous variables are reported as mean ± standard deviation. Fischer's Exact test and Wilcoxon matched pairs signed rank test were applied as appropriate. P value less than 0.05 was considered significant.

Results

The demographic characteristics of the patients are listed in (Table 1). The patient profile in the two groups was similar and no statistically significant differences were encountered.

Table 1. Characteristics of patients undergoing modified Blalock-Taussig shunt

Characteristic	PTFE group	SVG group	P value
Mean age months ± SD	16.62±23.68	6.46±7.41	0.131
Weight Kg ± SD	6.82±4.58	5.15±1.95	0.209
Diagnosis			
TOF	6	5	.7048
VSD PA	4	6	.6985
TGA VSD PS	4	4	.6797
TA VSD PS	1	0	.3091
RMBTS	8	12	.2453
LMBTS	7	3	.2453
Shunt Size			
3.5mm	5	2	.3880
4mm	8	8	.7144
4.5 mm	0	3	.2235
5mm	2	1	.5428
5.5 mm	0	1	.3091
Mean shunt size (mm±SD)	3.93± .53	4.2± .53	.174

PTFE: polytetrafluoroethylene, SVG: saphenous vein graft, SD: standard deviation, TOF: Tetralogy of Fallot, VSD: ventricular septal defect, PA: pulmonary atresia, TGA: transposition of great arteries, RMBTS: right modified Blalock- Taussig shunt, LBTS: left modified Blalock-Taussig shunt

There were three early deaths in the SVG group. 2 patients died within 4 hours after surgery in intensive care unit. Shunt patency could not be established in these patients before death. Third patient died after 27 days with respiratory infection, ventilator dependence and septicemia. There were no early deaths in the PTFE group (Table 2).

Three patients (1 early and 2 late) had documented graft thrombosis in saphenous vein group. Early graft thrombosis was on first postoperative day for which thrombectomy was performed but the graft again got blocked after 4 hours for which shunt revision was performed with PTFE graft. In saphenous vein group two patients had shunt blockage at 2 and 6 month of follow up respectively. First patient underwent shunt revision on the other side with a PTFE graft and other patient underwent a bi-directional Glenn shunt. 2 patients in PTFE group had early shunt blockage for which thrombectomy was done. There was no late shunt blockage in PTFE group.

Table 2. Results in patients undergoing modified Blalock-Taussig shunt

Characteristic	PTFE group	SVG group	P value
Operative time (minutes)	142.67±27.63	103±15.90	**0.001**
Early deaths	None	3	.2235
Chest drain output ml / m^2	464.43±375.18	76.56±92.08	**.001**
Re-exploration for thrombosis	2	1	.5428
Re-exploration for bleeding	3	0	.2835
Shunt seroma	5	0	**.0500**
Follow up (months ±SD)	8.06±1.49	6.44±3.58	0.122
Follow-up SPo2 %± SD	86.2±2.39	86.33±13.27	0.971
Need for late procedures	None	2	.4612
Definitive surgery	None	1	.3091
Infective complications	1	1	.4642

PTFE:polytetrafluoroethylene, SVG: saphenous vein graft, SD: standard deviation

Three patients in saphenous vein group and 5 patients in PTFE group underwent left sided shunt. In all other patients right sided shunt was performed. Average preoperative SaO_2 values were same in 2 groups. Post-operative SaO_2 values in saphenous vein group was 86.33±13.27% and in PTFE group was 86.2±13.27%. There was no incidence of over shunting or cardiac failure.

There was significant chest tube drainage in PTFE graft group compared to saphenous vein group. 3 patients were re explored for bleeding in PTFE group and there was no re-exploration in saphenous vein group for post-operative bleeding. 5 patients in PTFE group had evidence of seroma formation but no case of seroma was seen in saphenous vein group.

Operative time in vein group was 103-±15.90 min. In PTFE group it was 142.67 ±27.63 min mainly because of more time required for hemostasis. 3.5 to 5.5 mm veins were used and 3.5 to 5 mm PTFE graft were used.

Intra-operative thrill was palpable over the shunt in all patients. Shunt murmur was more prominent in PTFE graft compared to saphenous vein graft of same size despite well documented shunt flow in vein by echocardiography.

All hospital survivors underwent echocardiography at 3 months interval for shunt patency and pulmonary artery size, demonstrating similar degree of pulmonary

artery growth in both groups with patent shunt. 1 patient in both groups was admitted with fever after discharge, unrelated to the shunt. We did not notice any dilatation of the homograft vein on serial echocardiography.

Discussion

The search for an ideal substitute for systemic to PA shunts continues. Ideally such a substitute should be easy to implant, should be free of thrombotic complications, bleeding complications and peri-graft seroma formation. Additionally it should be inexpensive and should promote good pulmonary artery growth, should not produce distortion and should be easy to take down. Encouraged by its use in coronary artery bypass grafting[11,13,14] and peripheral vessel revascularization[15,16], homograft SVG has been used as a substitute for BTS with variable results[5-8]. Inspired by these reports we conducted this randomized controlled trial.

There were 3 in hospital deaths in the SVG group. Two patients died within 4 hours of surgery. These two patients had ventricular septal defect (VSD) with pulmonary atresia, and were thus dependent on shunt flow. Although we did not perform autopsy in these patients, but only abnormalities which were present at time of death were low oxygen saturation and hypokalemia, so until proved otherwise these mortality should be considered because of blocked shunt. One more patient died of respiratory infection after 27 days. Documented shunt thrombosis was seen in 2 patients in PTFE group and 3 patients in vein group. In PTFE group both thromboses occurred on first postoperative day and thrombectomy was performed. There was no shunt thrombosis in follow up period. At the same time vein group had 1 thrombosis on first operative day and other two at 2 months and 6 months of follow up respectively. If we presume the two other deaths to be due to shunt thrombosis then the number of episodes of shunt thrombosis rises to 5 in SVG group and 2 in PTFE group. Postoperative chest tube drainage was significantly less in vein group because of no needle hole bleeding. There was no incidence of seroma in vein group while 5 patients had seroma in PTFE group. Leblanc et al[17] have reported seroma in 20.4% without any relationship with heparin administration. Performing shunt operation was easy in vein group with less operative time than PTFE group because of superior maneuverability of vein.

Shunt takedown at second surgery should also be given consideration as PTFE is tough material and easy to localize while dissecting. Although, one may consider that take-down of a SVG shunt may be more difficult due to difficulty in localization and a significant risk to bleeding in case of accidental electro- cautery damage to the vein, Bogats et al[5] reported that they did not have any problem while dissecting these veins. In our study only one patient underwent bi-directional Glenn procedure after modified Blalock-Taussig shunt using the vein graft. In this patient the shunt was blocked so we did not dissect it.

Previous studies with modified shunt using vein as graft have shown variable results. Boggats et al[5] reported 2 early and 2 late deaths not related to procedure and one early occlusion in their 23 patients. They used both cryopreserved and antibiotic preserved veins without any difference. Danilowicz et al[6] reported their results in 16 patients and demonstrated 50% mortality (8 out of 16). 4 died in early postoperative period and four in later follow-up. Four patients had early graft thrombosis. Our own institute's unpublished data[18] on Blalock Taussig shunt with PTFE graft has shown thrombosis in 9.8% with early death in 8.9%. Erez et al[8] reported surprisingly excellent outcomes with commercially available cryopreserved homograft saphenous vein in infants less than 3 kg despite heparin reversal and median size of vein 3.0 mm.

Graft patency is not only dependent on graft material but length of graft, diameter, anastomotic stenosis, hematocrit, and distal runoff[11]. As our both groups are similar in these aspects, our results give fair idea of impact of graft material on patency.

Important issues when selecting a vein graft for the BT shunt are: Type of preservation technique: antibiotic preserved versus cryo-preserved, Immune reaction to homograft and matching and size of homograft vein to be used. Before preservation we size the vein in a distended state using calipers and this helps us to select an appropriate conduit during the shunt procedure.

Cryopreservation of homografts[9, 15] has been shown to be superior preservation technique as the donor cellular elements remain viable and prolong longevity of homograft. However previous experiment by Bogats et al[5] have demonstrated that there was no difference in patency of antibiotic and cryopreserved vein. A pathological study conducted by Martin et al[15] in suggests that despite good preservation of endothelium by cryopreservation, donor endothelium does not survive. Cryopreservation increases the cost of graft, therefore we opted for antibiotic preservation.

An experimental study conducted by Schwartz et al[16], has demonstrated that vein graft imposed very weak antigenic stimulation. Tice et al[11,19] while reporting their

experience with homograft saphenous vein explained that non cellular collagen and elastic tissue do not exhibit HLA antigens and saphenous vein allograft is not antigenic.

ABO compatibility has been used by Brockbank et al[9] and ABO compatibility was not given consideration by Bogats et al[5] in their experience with homograft veins in Blalock Taussig shunt without any adverse consequences. We have however used ABO compatible veins.

At our center we harvest and preserve the veins ourselves without involving any commercial firms and this helps us to cut down the costs of this procedure significantly. PTFE graft is supplied by manufactures in fixed sizes but homograft vein diameter is not fixed and uniform and depends upon inflating pressure. To avoid over perfusion of lung and pulmonary haemorrhage, we have been using a strategy of 3.5 to 4.0 mm shunt in children of less than 4 kg, 4-5 mm in patient of 4-7 kg and 5 mm and above graft for other children. We decided to use minimum size as per our criteria for PTFE graft, which we have been using. Because it is the subclavian artery size which acts as a flow regulator[1,4,20], even if the systemic pressure increases and size of vein increases after implantation, it should not lead to over shunting. Our early and follow-up results do not demonstrate any significant differences with the use of either substitute. If we exclude the patients who had early thrombosis, both groups had comparable palliation in the follow-up. We did not see any case of overflow in any of groups.

Study Limitations

Despite being a randomized study, the small numbers of patients in each group do not lend significant "statistical power" to this study. However it is an early attempt in this direction. Further the duration of follow-up is small. Long –term multi-institutional prospective randomized studies are required to address the issue of pulmonary artery growth and distortion and subsequent ease of takedown. Our follow up is short although one patient in vein group underwent bi-directional Glenn after 6 months and had adequate pulmonary arteries without any distortion. We do not have any data on the ease/difficulty of take-down of the SVG at re-operation; however as mentioned above, others have not found this to be difficult[5]. Also vein grafts are known to undergo aneurysmal dilatation, shrinkage or calcification in the long-term, but this is probably not a concern in these patients as the shunt procedure is used as a palliative procedure with a definitive procedure expected to be performed in 3 months to 1 year.

Conclusion

This study failed to demonstrate any benefit of homograft saphenous vein over PTFE graft in terms of thrombotic complications and mortality. Therefore, it may appear to be an inferior substitute compared to the PTFE. There was however less bleeding and peri-graft seroma formation in the SVG group. Our results must be interpreted with caution and further long-term studies are required to investigate if the SVG is superior to the PTFE graft for this purpose.

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