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執行單位：台大醫院小兒部

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經由主動脈至肺動脈分流管以氣球導管擴張肺動脈瓣膜閉鎖病人之肺動脈狹窄之效果評估

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一、中文摘要

合併肺動脈閉鎖之先天性心臟病人常需接受分流手術，所放置的分流管(Goretex tube)**常發生阻塞或造成肺動脈變形。過寺都需再接第二次分流管，我們利用氣球導管擴張術，治療分流管的狹窄。從** 1994 **年至** 1999 **年間，以氣球擴張術治療** 46 **例患有分流管阻塞的病人，擴張結果在** 42 **例**(91%)**明顯有效. 其中有** 28 **條肺動脈狹窄，我們順便擴張其中** 25 **條肺動脈，**14 **條擴張成功。血中氧氣濃度由** 74.4 ±4.3%**升高為** 80.8 ±3.6%**，後來有** 8 **例需接受第二次分流管手術，經追蹤** 11.6 ±5.4 **月後，**29 **病人接受另一次心血管攝影之後**26 **例開刀治療，僅有** 2 **例死亡。結論:當病人分流管阻塞而考慮放置第二條分流管時，氣球導管擴張術是個代替開刀的方式。**

關鍵詞： 分流管、肺動脈狹窄、PTFE **管**

Abstract

Objectives. The results of percutaneous balloon angioplasty for obstructed modified Blalock-Taussig (BT) or central shunts and pulmonary artery stenoses were studied to assess its role as an alternative to second shunt and surgical pulmonary artery angioplasty.

Background. Obstruction of a modified shunt and pulmonary artery stenosis related to the shunt or ductus is not infrequent. A second shunt with or without pulmonary artery angioplasty is required if the pulmonary artery size, morphology or age of the patient is suboptimal for definitive surgery.

Methods. From June 1994 to May 1999, balloon angioplasty for obstructed systemic-to-pulmonary artery shunts was performed in 46 patients, with ages ranging from 1 month to 7.4 years (2.2±1.9 years). Among the 46 patients, 32 had a modified BT shunt, 5 had bilateral shunts, 7 had a modified central shunt and 2 had both modified BT and central shunt. Stenoses were seen in 27 main branch pulmonary arteries and interruption was present in 3. A concurrent balloon angioplasty was attempted in 28 main branch pulmonary arteries, but performed in 25 vessels.

Results. Balloon dilation for obstructed modified shunts was considered to be effective in 42 patients (91%), while angioplasty for pulmonary artery stenosis was effective in 14 vessels, and non-effective in 11 vessels. After balloon dilatation angioplasty, oxygen saturation in the aorta increased from 74.4±4.3% to 80.8±3.6% ($P<0.01$) in these 42 patients. One patient died of pneumonia. Eight patients required an additional modified BT shunt soon after the procedure because of severe stenosis or interruption at main branch pulmonary artery. After a mean follow-up period of 11.6±5.4 months, 29 patients underwent a repeated imaging study to evaluate the morphology and size of the pulmonary arteries. Of these

29 patients, 26 underwent open heart surgery with 2 mortalities.

Conclusions. When a second shunt is under consideration because of obstruction of the modified shunt, balloon angioplasty is a possible alternative procedure. Pulmonary artery stenosis, if present, can be simultaneously dilated.

Keywords: 1.modified systemic-pulmonary artery shunt, 2.pulmonary artery stenosis, balloon angioplasty, 3.polytetrafluoroethylene (PTFE) tube.

二、緣由與目的

Introduction: Primary repair in many congenital heart anomalies among younger infants is on the increase. However, many patients in early infancy still require a palliative systemic-pulmonary artery shunt (1,2). The classic Blalock-Taussig (BT) shunt is a widely accepted palliation for certain forms of congenital heart disease where an increase in pulmonary blood flow is required. A modified BT shunt, performed by placing a polytetrafluoroethylene (PTFE) tube between the pulmonary artery and the subclavian artery, is increasingly common since it provides satisfactory long-term results with low morbidity (3-5). In some instances, a modified central shunt is employed to palliate certain forms of cyanotic heart disease (6). Occlusion or stenosis of a systemic-pulmonary artery shunt is not infrequent (7-9), and may result in aggravated cyanosis. A second shunt may be required if the pulmonary artery size, weight, or the age of the patient is suboptimal for definitive surgery. Balloon angioplasty for a stenosed classic BT shunt has been performed with varied success (10-14). However, reports of angioplasty for a systemic-pulmonary artery PTFE shunt are relatively rare (15-17). This study describes the results of the dilation of obstructed PTFE shunts and simultaneous angioplasty for pulmonary artery stenoses in patients with complex heart disease.

Methods:

Patients. The study protocol was approved by the Human Research Committee of this institution. Over a 60-month period from June 1994 to May 1999, 70 patients in this institution were diagnosed with a stenosed modified systemic-pulmonary artery shunt after cardiac catheterization and angiography. Of them, 21 patients were considered as candidates for definitive repair. The remaining 49 patients were judged to require another palliative procedure prior to definitive repair because of suboptimal pulmonary artery size or ages. Attempts to dilate the stenotic shunt failed with 3 patients. A total of 46 patients who underwent dilation of the obstructed PTFE shunt were enrolled in this study. Their ages ranged from 1 month to 7.4 years (2.2 ±1.9 years, mean ± SD). Their body weight ranged from 3 to 18.1 kg (9.4 ±4 kg). There were 29 boys and 17 girls. Two patients were intubated with ventilatory support. Seven patients required continuous infusion of PGE_1 to maintain O_2 saturation above 75%. Eight patients required continuous oxygen inhalation. Of the 46 patients, 32 had a modified BT shunt, 5 had bilateral modified BT shunts, 7 had a modified central shunt and 2 had both modified BT shunt and central shunt. The diameters of the shunts implanted ranged from 3.5 mm to 6 mm. Among the 46 patients, 24 had main branch pulmonary artery stenosis and 3 had interruption of a pulmonary artery. Of the 24 patients with main branch pulmonary artery stenosis, the stenosis was found in 27 main branch pulmonary arteries: 12 were juxtaductal stenoses, 4 long segment hypoplasia of central pulmonary arteries, 9 shunt related stenoses and 2 multiple stenoses related to both shunt and ductus. Dilation of the stenotic lesions was attempted in 28 main branch pulmonary arteries: 27 with stenosis and 1 with acquired interruption.

Methods. All except 7 patients who were younger than 2 months received premeditation with a cocktail of meperidine, promethazine, and chloropromazine 30 minutes before cardiac catheterization. The 7 patients who were younger than 2 months

were sedated with ketamine, valium or dormicum. After local anesthesia, femoral vein and artery were percutaneously accessed. A 5 Fr or 6 Fr sheath was used for cannulation of femoral vein or artery. Ketamine, or dormicum was used as required. Heparin 50 U/kg was routinely administered. After hemodynamic studies, a selective angiogram at the distal subclavian artery was obtained by employing a balloon occlusion technique to delineate the site of obstruction in patients with a modified BT shunt. The narrowest diameter of the stenotic lesion in the modified B-T shunt or subclavian artery was measured in each patient. An angiogram of the aortic root or descending aorta was performed on those with a central shunt. Following subclavian arteriography or aortography, a right Judkins catheter (Cordis, Miami, FL,) or headhunter catheter (Balt, Montmorency, France) was advanced to the PTFE graft. A soft tip 0.035 Radifocus guide-wire (Terumo Corp., Tokyo, Japan) was then positioned in the pulmonary artery through the 4Fr or 5Fr right Judkins catheter or head hunter catheter. After retrieving that catheter, a low profile (5Fr) short taper balloon catheter (Schneider, Bulach, Switzerland) was advanced along the guide-wire to the stenotic lesion. The balloon was inflated several times by applying a pressure of 3 to 8 atmospheres. Each inflation lasted less than 10 seconds. For the sole patient with total occlusion of the shunt, a floppy tip 0.014 coronary guide-wire was gently advanced along the occluded PTFE graft, and an ACS coronary balloon catheter (Advanced Cardiovascular Systems Inc. , Temecular, CA) was advanced to the shunt to perform angioplasty. Then, progressively larger balloon catheters were used to dilate the occluded shunt. Of the 5 patients with bilateral modified BT shunts, both shunts were dilated in 2 patients and one shunt was dilated in 3. In the 2 patients with both modified BT shunt and central shunt, the central shunt was completely occluded and the modified BT shunt was dilated.

The interval between placing a modified shunt and attempted angioplasty ranged from 27 days to 6.8 years. The size of the balloon used was generally equal to or slightly larger than the shunt diameter. When the balloon catheter selected could not pass the stenotic lesion, a balloon catheter of a smaller size or coronary balloon catheter was used, then progressively larger balloon catheters were employed. When pulmonary artery stenosis was present, the same guide-wire was postioned beyond the stenosis. Angioplasty for pulmonary artery stenosis was performed concurrently employing the same balloon catheter through the PTFE shunt. A pressure of 3 to 8 atmospheres was applied to inflate the balloon. Then, larger sized balloon catheters were utilized to dilate the pulmonary artery stenosis to the desired diameter. The size of balloon selected for pulmonary artery angioplasty was generally equal to or 1 to 2 mm larger than the pulmonary artery diameter proximal to stenosis. When the desired size balloon catheter could not pass the PTFE shunt, a smaller size balloon catheter was used. All patients were monitored with pulse oxymeter and ECG during cardiac catheterization and angioplasty procedure. A post-angioplasty angiogram was performed to evaluate the effectiveness of angioplasty. The narrowest diameter of the stenotic lesion of the modified BT shunt or subclavian arteries was measured on the repeated angiogram. Fifteen minutes after angioplasty, a second oxymetric study was performed. In the 8 patients requiring supplemental oxygen prior to and during balloon angioplasty, repeat oxygen saturations were measured while receiving the same fractional inspired oxygen. We arbitrarily defined effective balloon dilatation for obstructed modified shunts as an increase in the shunt diameter $\geqq$20% or increase in systemic O_2 saturation $\geqq$ 3%. We also define effective pulmonary artery angioplasty as an increase in diameter of pulmonary artery > 50%. For patients with multiple stenoses in one vessel, an increase >50% in all stenotic lesions was regarded as effective angioplasty.

Statistical analysis. Data are expressed as mean $\pm$SD. A paired t test was used to compare the systemic O_2 saturation data, diameter of narrowest dimension in a

modified shunt and pulmonary artery before and after angioplasty, and the McGoon ratio and narrowest dimension in a shunt and pulmonary artery after angioplasty and preoperative evaluation.

三、結果

Results

Balloon angioplasty for stenosed shunts and pulmonary arterie. Information about these 46 patients is listed in Table I. A flow chart was also provided (figure 1). All patients tolerated the procedure. Of the 7 patients with a central shunt, the stenosis occurred at the anastomotic sites and/or graft. Of the 39 patients with a modified BT shunt, stenosis was confined to a subclavian artery in 5, in the graft alone in 9, at the anastomotic sites in 6, in both graft and anastomotic site in 12 and in both the subclavian artery and graft in 7. The balloon-to-PTFE tube diameter ratio ranged from 0.8 to 1.5 (mean 1.13 ± 0.17). A post-angioplasty subclavian arteriograms or aortograms confirmed that the stenoses in the PTFE shunts or subclavian arteries were partially or completely relieved in all 46 patients. (Figure 2) Excluding the 7 patients with a central shunt in whom measuring the dimension of stenotic lesion was suboptimal, the mean diameter of the stenotic lesions in the grafts or subclavian arteries increased from 2.2 ± 0.7 mm to 3.2 ± 0.6 mm ($p<0.01$) following balloon angioplasty in the 39 patients with modified BT shunts. Judging from the post-angioplasty angiogram, pulmonary blood flow increased in most patients. Balloon angioplasty for the modified shunt was considered effective in 42 patients (91%) and non-effective in 4. Dilatation of pulmonary artery stenosis or interruption was accomplished in 25 main branch pulmonary arteries, but failed in 3. The causes of technical failure in the 3 vessels were inability to pass a floppy guide-wire across the stenotic lesion in 2 vessels and failure to pass a balloon in 1. Excluding the patient with acquired interruption of right pulmonary artery, the ratio of balloon size to narrowest diameter of pulmonary artery stenosis ranged from 1.8 to 3.1(2.3 ±0.5). In the 25 vessels, the mean diameter of the stenotic pulmonary artery segment increased from 2.8 ± 1.3 mm to 4.5 ± 1.9 mm ($p<0.01$) following angioplasty. Dilation of pulmonary artery stenosis was considered to be effective in 14 vessels where perfusion to pulmonary arteries distal to the stenotic lesion was significantly increased following dilation. (Figure 3) Of the 11 vessels with ineffective pulmonary artery angioplasty, 4 were long-segment central pulmonary artery hypoplasia, 2 were shunt related stenosis, 2 were juxtaductal stenosis, 2 were multiple stenoses, and the remaining 1 was an acquired interruption of right pulmonary artery following a modified shunt in which there was significant stenosis remained requiring another shunt.

Following the angioplasty, the mean oxygen saturation in the aorta increased from 74.4±4.3% to 80.8±3.6% in these 46 patients. ($P<0.01$) All except one had an increase in systemic O_2 saturation ranging from 2 to 15%. The sole patient, who had slight decrease in systemic O_2 saturation immediately following angioplasty, had significant increase in systemic O_2 saturation measured with pulse oxymetry on the next day. The PGE_1 could be discontinued in the 5 out of 7 patients within 7 days. The remaining 2 had required another shunt because of juxtaductal coarctation of a pulmonary artery. One of the 2 patients who were intubated with ventilatory support, could not be weaned from respirator and died of pneumonia. Of the 8 patients requiring O_2 inhalation, the oxygen could be discontinued after the procedure in 6. A total of 8 patients underwent a modified BT shunt soon after the procedure because of a severe stenosis or interruption in a pulmonary artery. The remaining 37 patients were discharged with antiplatelet therapy (aspirin 5 mg/kg/day).

Complications. No severe complications were encountered. No patient developed hemoptysis. Intimal tear of a pulmonary artery was found in 7 patients. A distal branch pulmonary artery was occluded following angioplasty in 1. (Figure 4) A transient drop in O_2 saturation was experienced in 38 patients, who were treated

by O_2 inhalation through a mask or hood and prompt withdrawal of the balloon catheter to the aorta. Six patients required heparin or streptokinase infusion because of transient loss of a femoral pulse.

Follow-up. During follow-up, one patient died of an accident and one with asplenia syndrome died of an overwhelming infection. One was lost to follow-up. Twenty-nine patients underwent imaging studies for pulmonary artery size and morphology 6 to 26 months (11.6±5.4months) following the initial intervention : 4 with a computerized tomography and 25 patients with an angiogram. The shunts which were dilated in previous balloon angioplasty were patent in all except one with complete occlusion. Two had recurrent stenosis of the shunt. In 23 patients with adequate images of BT shunts, mean dimension of the stenotic lesion in the modified BT shunt was 3.1 ±1.1 mm, as comparing to the mean diameter 3.3 ±0.7 mm measured immediately following angioplasty, there is no significant difference. ($p=0.34$) Of the 18 pulmonary artery which was dilated in previous angioplasty, the mean diameter of the narrowing segment increased from 5 ±1.8 mm after angioplasty to 5.4 ± 1.8 mm on the follow-up angiogram. ($p<0.05$) There were no restenosis occurred in the pulmonary arteries in which previous balloon angioplasty was effective. One underwent a concomitant pulmonary artery balloon angioplasty with further increase in diameter of the stenotic lesion. (Figure 5) An aneurysm, which was not detected in previous angioplasty, was found at the anastomotic site of a shunt in a pulmonary artery in 1. Excluding the 2 patients with interruption of a pulmonary artery, the McGoon ratio (sum of the diameter of left and right pulmonary artery before first lobar branches / the diameter of the descending aorta at the level of diaphragm) increased from a mean of 1.49±0.2 before angioplasty to 1.58± 0.16 ($p<0.01$) at follow-up in the 27 patients. Of the 29 patients, 26 underwent an open heart surgery: 4 total cavopulmonary connection, 6 bidirectional Glenn shunt, 7 Rastelli operation, 1 ventricular septation, 3 double switch, 1 Kawashima procedure, 1 right ventricular outflow tract patch, 1 re-routing of pulmonary venous confluence to atrium and a shunt implantation, and 2 repair for tetralogy of Fallot. Of the 26 patients, a concurrent pulmonary artery angioplasty was performed in 8. There were 2 mortalities. One underwent a modified BT shunt and pulmonary artery augmentation because of a long segment central pulmonary artery stenosis and inadequate pulmonary artery index. Two await open heart surgery. One patient (case 15) who survived bidirectional cavopulmonary shunt and pulmonary artery reconstruction developed severe atrioventricular valve regurgitation and impaired ventricular function. She underwent a cardiac transplantation with success. Excluding those who underwent a surgery, there were 9 patients available for follow-up. After a mean follow-up period of 7.8±6.3 months, the mean O_2 saturation measured with pulse oxymeter was 79.2 ±2.6% in these 9 patients.

四、結論

Dilation of PTFE shunts as an alternative to a second shunt. The percutaneous balloon dilatation technique has been widely employed to treat congenital valvular and vascular stenosis with satisfactory results (18). This technique has been successfully applied in patients with stenosed standard BT shunts, and can be an alternative procedure to a second shunt (10-14). Therefore a standard BT shunt is recommended as the first choice of systemic to pulmonary artery shunt since it is uniquely dilatable (14). In the current study, dilation for stenosed modified shunts, which was accomplished in 46 out of 49 patients attempted, was effective in 42 patients (91%). Advocated is a modified BT shunt or a modified central shunt as an initial palliation in complex cyanotic heart disease since dilation can be performed in most patients with stenosis of the modified shunts. An effective dilatation for a stenosed PTFE shunt may eliminate the need for a second shunt, particularly for patients with complex heart disease in whom further pulmonary artery

distortion may occur following a shunt (15-17,19). Although the bidirectional cavopulmonary shunt and a concurrent pulmonary artery angioplasty have been recommended for infants who are Fontan-type surgery candidates (20), balloon dilatation of the obstructed shunt and the stenosed pulmonary artery can serve as an alternative procedure.

Technical aspects and complications of dilating stenosed modified shunts. Stenosis of the modified PTFE shunt can occur in the subclavian artery adjacent to anastomotic site, the graft and anastomotic sites. The stenosis at anastomotic site may be resulted from scar formation while the stenosis in the PTFE tube may be due either to fibrous neointimal peel or to organized thrombosis (17). The mechanism of action of balloon angioplasty in dilation of the PTFE tube may involve dissection and disruption of the fibrous neointimal peel or thrombi. Employing a balloon slightly larger than the graft diameter appears to be beneficial and safe, although an aneurysm at anastomotic site of a PTFE tube and pulmonary artery was seen in one patient. This could be a result of a tear at the anastomotic site. Dislodgment of intimal lining causing thrombosis of a distal branch pulmonary artery could be a problem following dilation of the modified shunt. In the patient who developed obstruction of a distal branch of a pulmonary artery, a right ventricular outflow tract reconstruction was performed without any major complication. In the current study, the interval between a shunt placement and balloon angioplasty was no less than 3 weeks since immature scar tissue may not tolerate dilation with a high pressure and oversized balloon which was selected for dilating both the shunt and pulmonary artery (21). For balloon angioplasty for early postoperative shunt failure, a balloon with a diameter smaller than shunt has been recommended (16). Advancing a catheter to a modified BT shunt at the left subclavian artery via retrograde aortic route in a patient with a right aortic arch can be difficult. An anterograde route from femoral vein to the aorta is a possible alternative approach in such patients with double outlet right ventricle or tetralogy of Fallot (14). A modified central shunt can be entered with a right coronary catheter without much difficulty, but successful balloon angioplasty for a modified central shunt has rarely been reported in literature. There was failure in balloon angioplasty for stenosed PTFE shunts occurred in early experience here. Since early 1995, after the procedure has become more familiar, almost every case has been successful.

Simultaneous dilation of pulmonary artery stenosis. Pulmonary artery distortion following a systemic-pulmonary artery shunt is common (7,8,19). Pulmonary artery stenosis related to ductus is also frequent in complex cyanotic heart disease (22-24). In the presence of pulmonary artery stenosis, growth of pulmonary artery distal to stenosis can be hampered. A successful angioplasty may provide relief of pulmonary artery stenosis, improve perfusion to the underperfused lung and growth of distal pulmonary artery, greatly increasing the chance for later Fontan-type or Rastelli surgery (21). Surgical angioplasty for pulmonary artery stenosis related to a ductus or shunt may be a problem and, for this reason, balloon dilatation of pulmonary artery stenosis prior to definitive surgery would be an alternative to surgical reconstruction of pulmonary arteries (22-25). Several complications from balloon angioplasty for pulmonary artery have been reported in literature including aneurysm, hemoptysis, heart block and death (21,26). Tearing in intima and media, which was not infrequent following balloon angioplasty, was a mechanism and also a predictor for successful pulmonary artery angioplasty (26,27). The success rate of angioplasty for branch pulmonary artery stenosis was reported to be 58% (21). In two reports, surgery-related pulmonary artery stenosis was considered to be amenable to balloon dilation (27,28). In a report by Gentles et al., using a high pressure balloon in dilation of surgery-related lesions was nearly always successful (26). In the current study, balloon angioplasty for pulmonary artery stenosis was performed through a modified shunt. Branch pulmonary

artery stenosis was effectively dilated in 14 out of 28 attempts (50%). The balloon size selected in the current study was generally smaller than those recommended in literature (21,26). This was attributed to the relatively smaller caliber of PTFE shunt allowing for passage of smaller size balloons. Balloon angioplasty for neonates or young infants with ductus-related pulmonary artery stenosis may not provide long-term relief of stenosis, since closure and fibrosis of ductal tissue may lead to restenosis (24). Restenosis of pulmonary artery to predilation size occurred in 10 to 16% patients (21,26). In this series, no restenosis was detected in the pulmonary arteries which were effectively dilated.

Study limitations. There were several limitations in this study. This is a retrospective study. The definitions of success in angioplasty for stenosed shunts and pulmonary artery stenosis are quite arbitrary. We used an increase in shunt diameter ≧20% or systemic O_2 saturation ≧3% as criteria for effective dilation for shunts. However, the increase in systemic O_2 saturation following the procedure can not be attributed to the effect of dilation for the shunts alone. A concurrent angioplasty for pulmonary artery stenosis may also contribute to relieve hypoxemia. An increase of pulmonary artery diameter >50% may not be a perfect criterion for effective pulmonary artery angioplasty. In many patients with effective angioplasty, there are varying degrees of pulmonary artery stenosis left that may compromise later Fontan circulation. Eight patients in the current series required a patch angioplasty for pulmonary arteries at the time of an open heart surgery. Understanding the long-term effects of balloon angioplasty for branch pulmonary artery stenosis requires further studies. We consider many of the patients may need a endovascular stent placement in the future (29).

Conclusions. When a second shunt is under consideration because of obstruction of a PTFE shunt, balloon angioplasty to dilate the stenotic sites may be an alternative to another shunt. Balloon dilatation for a pulmonary artery stenosis, either ductus or shunt-related, can be performed concurrently. This is particularly true for patients who are candidates for Fontan- type surgery since a second shunt may incur risk and further distort pulmonary arteries.

五、References

1. Marbarger JP, Sandza JG, Hartmann AF, Weldon CS. Blalock-Taussig anastomosis. Circulation 1978;58（suppl II）:I 73-7.
2. Stewart S, Alexson C, Manning J. Long-term palliation with the classic Blalock-Taussig shunt. J Thorac Cardiovasc Surg 1988; 96: 117-21.
3. Moulton AL, Brenner JI, Ringel R, et al. Classic versus modified Blalock-Taussig shunts in neonates and infants. Circulation 1985; 72 Suppl II: 35-44.
4. Bove EL, Kohman L, Sereika S, et al. The modified Blalock-Taussig shunt: analysis of adequacy and duration of palliation. Circulation 1987;76 (suppl III):III 19-23.
5. Ilbawi MN, Grieco J, DeLeon SY, et al. Modified Blalock-Taussig shunt in newborn infants. J Thorac Cardiovasc Surg 1984;88:770-5.
6. Barragry TP, Ring WS, Blalchford JW, Foker JE. Central aorta-pulmonary artery shunts in neonates with complex cyanotic congenital heart disease. J Thorac Cardiov Surg 1987;93:767-74.
7. Ullom RL, Sade RM, Crawford FA, Ross BA, Spinale F. The Blalock-Taussig shunt in infants: standard versus modified. Ann Thorac Surg 1987;44:539-43.
8. Tamisier D, Vouhe PR, Vernant F, Leca F, Massot C, Neveux J-Y. Modified Blalock-Taussig shunts: results in infant less than 3 months of age. Ann Thorac Surg 1990;49:797-801.