PEDIARTRIC MID-TERM COMPLICATIONS OF TOTAL CAVOPULMONARY CONNECTION WITH EMPHASIS UPON THROMBOEMBOLISM

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ABSTRACT

Background :Children with congenital heart disease constitute a major proportion of children seen in tertiary hospitals with thromboembolism (TE) . Total Cavo-pulmonary Connection (TCPC) surgery can result in TE and other complications as protein-losing enteropathy (PLE), arrhythmias, ventricular dysfunction & neurologic sequelae . There are few well designed studies in the literature determining the epidemiology of thrombosis after TCPC operarion, however, TE has been diagnosed in children, especially following the BT shunt and the Fontan surgery (1).**Aim of work.** To revise King Faisal Specialist Hospital & Research Center (KFSH&RC)-Jeddah in TCPC in an attempt to provide evidence-based recommendations for postoperative management of theses patients. **Methods**. Sixty-five pediatric patients who underwent TCPC were retrospectively reviewed. The mean age at operation was 4.9 ± 1.9 years. The following items were considered as the potential risk factors according to previous reports: (1)aged more than 4 years (7 cases); (2)heterotaxy (8 cases); (3) systemic ventricular ejection fraction less than 60% (6cases); (4) atrioventricular valve regurgitation moderate or greater (4 cases); (5) mean pulmonary arterial pressure 15 mmHg or greater (3 cases); (6) pulmonary arterial resistance 4.0 wood units or greater (9 cases); (7) arrhythmias (8 cases); (8) protein-losing enteropathy (3 cases); (9) previous TCPC procedure (2 cases); (10) systemic ventricular outflow obstruction (1 case); and (11) end-diastolic pressure of the systemic ventricle 11 mm Hg or higher (5 cases). **Results.** The median follow-up period was 43 (3-96) months . Twenty-one patients had at least 1 risk factor (range, 1 to 4). Early postoperative complications comprised ascites 2 (3%) cases; prolonged pleural effusion 12 (18.4 %)cases; low cardiac output syndrome 4(6.1%) cases; significant postoperative bleeding 3 (4.6%) cases; acute renal failure 6 (9.2%) cases; and oxygen desaturation 4 (6.1%) cases; late postoperative complications took the form of new onset of PLE 6 (9.2%) cases; hepatic failure 1 (1.5%) case; worsening heart failure 5 (7.6%) cases; atrial tachyarrhythmias 5 (7.6%) cases; sick sinus syndrome 2 (3%) cases; and thrombosis 4 (6.1%)cases. There was 2 early deaths and 5 late deaths. The overall mortality was 10.8%. Comparing the late survivors and nonsurvivors, no statistical significance was identified in the above risk factors. **Conclusions.** The majority of the pediatric TCPC candidates tolerated the TCPC procedure in the early postoperative period. The threshold for diagnostic and interventional cardiac catheterization should be lowered post-TCPC .It seems reasonable to recommend chronic oral anticoagulation in those patients despite it did not prevent thrombosis in our patients who developed TCPC circuit blockade .

INTRODUCTION

Before the Fontan operation, complex cardiac anomalies that were unsuitable for biventricular repair were palliated by pulmonary artery banding or systemic-to-pulmonary shunts. Nevertheless, the life expectancy was only two to three decades.

The introduction of the Fontan operation dramatically changed the management of patients with a functional single ventricle. Forty years after the first description of total right heart bypass (2), one or another modification of the Fontan operation has become one of the most frequently performed operations for congenital heart

disease. The separation of systemic and pulmonary venous returns results in near-normal systemic oxygen saturation and normalizes the volume work of the systemic ventricle. Now children, adolescents, and adults with a functional single ventricle can experience a normal lifestyle.

PATIENTS AND METHODS

Sixty-five patients underwent TCPC at King Faisal Specialist Hospital & Research Center -Jeddah between December 2001 and January 2010. The medical and surgical records of all patients were retrospectively reviewed. The data collected included demographic data, cardiac diagnosis, surgical data, and operative procedures. The preoperative echocardiographic data, catheterization data, and laboratory data were reviewed. Data also included the postoperative length of hospital stay, length of stay in the cardiac intensive care unit, duration of mechanical ventilation, duration of chest tube drainage, and outcome. The overall mortality was defined as death occurring from the time of surgery to the most recent follow-up. Early postoperative death was defined as that occurring in the hospital or less than 30 days after surgery. Late complications reviewed included postoperative issues such as pleural effusions, pericardial effusion,ascites, PLE, arrhythmia requiring treatment, ventricular dysfunction, neurologic sequelae, and thromboembolic events.

Statistical Analysis

The relationships between late mortality and the risk factors were examined with Fisher's exact test. A p value of less than 0.05 was considered to be significant.

RESULTS

Sixty-five pediatric patients with congenital heart disease underwent TCPC . There were 32 males and 33 females. The mean age at operation was 4.9± 1.9_years . The summary of their profiles is described in Table 1. The median follow-up period was 43(3-96)months. There was 2 early deaths from cardiac tamponade due to bleeding after removal of the temporary pacing wire, and 5 late deaths due to heart failure.. The overall mortality was 10.8%. Comparing the late survivors and nonsurvivors, no statistical significance was identified regarding the risk factors. The details of the latest postoperative data and postoperative complications are shown in Tables 2 & 3, respectively. All of these patients receive anticoagulation therapy.

All patients underwent TCPC using extracardiac conduit . The indication for surgery included cyanosis (n =43), decreased exercise tolerance (n =27). The mean cardiopulmonary bypass time was 149 ± 51 minutes . The mean aortic cross-clamp time was 81 ± 39 minutes . The median duration of mechanical ventilation was 4 hours (range, 0 to 487), and 13 patients could be weaned from the ventilation support within 24 hours after the operation. The median length of intensive care unit stay was 6 days (range, 1 to 32), the median duration of chest tube drainage was 7 days (range, 4 to 71), the median length of postoperative hospital stay was 41 days (range, 11 to 163) .The final conditions of these patients before the TCPC completion were post–bidirectional Glenn (BDG) procedure (n =46) & post-Kawashima procedure (n =19) . Twenty-three associated operations were performed, and included creation of a fenestration (n = 7), common atrioventricular valve repair (n = 1), atrioventricular valve replacement (n = 1), pulmonary arterioplasty (n = 2),atrial septectomy (n = 15), and implantation of pacemaker leads (n = 4).

Table 1. Patients' Profiles pre-TCPC

	S/P Fontan (n=46)		S/P Hepatic vein incorporation (n=19)	
	Male	Female	Male	Female
Number(%)	24 (52.2)	22 (47.8)	8 (42.1)	11 (57.9)
	Mean (range)	Mean (range)	Mean (range)	Mean (range)
Age (years)	5.1 (3-7.8)	5 (3.1-7.8)	4.9 (3-7)	4.8 (3.2-6)
Body weight (kg)	16 (12-23)	15.5 (11-21)	15 (11.5-19)	14.2(11.3-18)
Body surface area (m^2)	0.4 (0.3-0.7)	0.35 (0.3-0.6)	0.3 (0.29-0.5)	0.3(0.32-0.55)
Sa O2 (%)	86.9(69-100)	85.4(68-99)	87.1(72-100)	88.3(75-99)
TP(mg/dL)	6.5(5.5-7.9)	6.9 (4.1–8.9)	6.8 (4.5–8)	7 (5.4–7.7)
Albumin(mg/dL)	4.4(2.7-4.6)	4.3 (2.9–4.9)	3.5 (2.3–4.7)	3.7 (2.1–4.8)
mPAP(mm Hg)	11.2(7.0–18.0)	10.9(6.0–18.0)	10.8(6.0-15.0)	10.4(6.0–14.0)
PVR (wu)	2.5 (1.2–3.9)	2.3 (1.1–4.7)	2.2(1.4–4.6)	2.6(1.3-4.1)
CT(%)	57(40-81)	58 (43–78)	56 (45–75)	59 (43–75)
EF(%)	61(52-73)	52 (35–71)	65 (54–75)	57 (35–75)

CT = cardiothoracic ratio; EF = ejection fraction, mPAP = mean pulmonary arterial pressure; PVR = pulmonary vascular resistance; SaO2 =arterial oxygen saturation; TP = total protein, TCPC = total cavopulmonary connection, wu = wood's unit

Table 2. Postoperative Data on the Latest Follow-Up

	S/P Fontan(n=46)	S/P Hepatic vein incorporation (n=19)	Total
	Median(Range)	Median(Range)	Median(Range)
Follow-up, months	46 (14–96)	39 (3–75)	43 (3–96)
SaO2 (%)	93 (82–100)	94 (83–100)	93 (82–100)
CT (%)	51 (40–63)	53 (42–64)	52 (40–64)
Ejection fraction (%)	62 (32–86)	59 (30–89)	66 (30–89)
TP (mg/dL)	6.4 (4.8–8.6)	6.5 (5.2–8.6)	6.8 (4.8–8.6)
Albumin (mg/dL)	4.1 (2.8–4.6)	3.6 (2.2–4.7)	3.9 (2.2–4.7)
EDP	7 (2–14)	6 (4–11)	7 (2–14)

CT=cardiothoracic ratio; EDP = end-diastolic pressure of systemic ventricle; SaO2 = arterial oxygen saturation; TP = total protein.

Four patients underwent pacemaker implantation 2 for sick sinus syndrome 1 for complete heart block & 1 for 2nd. Degree AV block ,Wenckebach phenomenon. Although 4 patients needed home oxygen therapy in the early postoperative period (Table 3), all of them were weaned from home oxygen therapy.

Thrombo-embolism

Patient 1

A 40 days old baby girl was seen at KFSH&RC clinic with DORV, subpulmonic VSD , PS, d-malposed great

arteries & tiny PDA. She had bilateral SVCs with a bridging vein. The RV was bipartite with no trabecular portion. The tricuspid valve annulus was overriding the ventricular septum with chordal attachment to the crest. A sub-pulmonary conus was present with a PS gradient of 36 mmHg. At the age of 4 months , a diagnostic catheterization revealed an RVEDP of 15 mmHg , LVEDP of 13 mmHg , a mean PAP of 18 mmHg , & a PVR 1.4 WU. A bidirectional Glenn shunt , PA banding , atrial septectomy & PDA ligation were performed at the age of 5 months. Till the age of 5 months , the patient had sinus rhythm then episodes of junctional rhythm & junctional tachycardia were reported and became more frequent later on. Initially , the RV was small , serial echoes revealed an increase in RV size.

Cardiac catheterization at the age of 2.3 years revealed an RV size that is 2/3 of the LV size and it seemed difficult to tunnel the LV to Aorta. Follow up was done so long as her saturation remained in the high 80s. Re-catheterization at the age of 4.5 years showed a mean PAP of 6 mmHg & an RVEDP of 6 mmHg.

Table 3. Postoperative Complications

Complications	Number of Patients		
	S/P Fontan(n=46)	S/P Hepatic vein incorporation (n=19)	Total (n=65)
Early Complications:			
-Ascites	1	1	2
-Prolonged pleural effesion(>7 days)	7	5	12
-Low-output syndrome	3	1	4
-Postoperative bleeding requiring mediastinal thoracic exploration	2	1	3
-Acute renal failure requiring CHDF	3	3	6
-Desaturation requiring HOT	4	0	4
Late Complications:			
-New onset of PLE	5	1	6
-hepatic failure	0	1	1
-Worsening heart failure	4	1	5
-Atrial tachyarrhythmia	3	2	5
- Sick sinus syndrome	1	1	2
-Thrombo-embolism	3	1	4

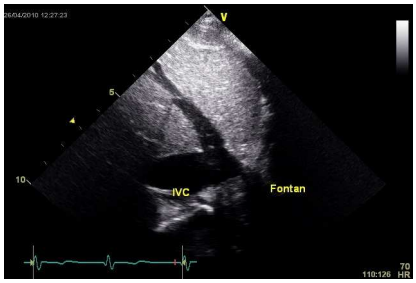
CHDF=continuous hemodiafiltration; HOT=home oxygen therapy;PLE= protein-losing enteropathy.

PEIATRIC

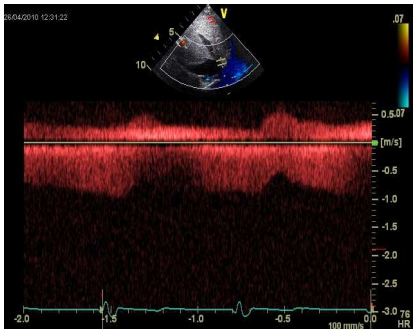
An EC Fontan was done at the age of 4.5 years using a contegra size 20 mm to connect the IVC to the PA confluence. In the ICU , the patient had history of early post-operative hemothorax, sluggish IVC flow and low urine output. Cardiac catheterization elucidated stenosis at the junction of the IVC to contegra, sluggish Fontan/IVC flow, a mean pressure of 16 mmHg at Fontan circuit , patent Glenn shunt & an LVEDP of 10-12 mmHg. At this point no intervention was made as there was no gradient across the Fontan stenosis.

Two weeks later , she was seen at the clinic with persistent vomiting & abdominal pain .Chest x-ray showed significant pleural effusion. Echo showed mild pericardial effusion & patent Fontan connections with reduced flow velocity . She had significant hepatomegaly not responding to conservative management , therefore , cardiac catheterization was performed revealing thrombotic blockade of the entire Fontan circuit and the LPA .Streptokinase infusion was given in the ICU for 48 hours. Repeat catheterization showed significant declotting of Fontan connections with improved but still sluggish blood flow . Two 45 mm covered stents were used to stent the Fontan circuit. Post-stenting , some improvement was noticed in liver size and abdominal pain ,echo revealed patent Fontan connections with reduced Laminar flow in IVC and hepatic veins ,Patent right Glenn with laminar flow ,no SVC or IVC dilatation. At the time of discharge ,her liver size regressed to 3 cm below the right costal margin in midclavicular line , she had better oral feeding tolerance and no more abdominal pain.

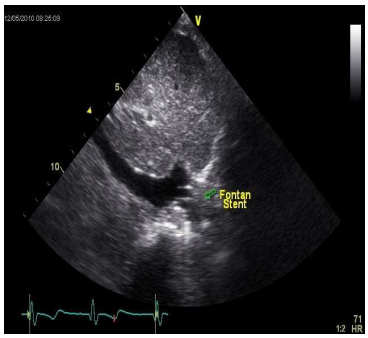
The patient was managed to be extubated & discharged home in a stable condition.



Two-dimensional image of patient 1 showing
dilated IVC & distal hepatic vein.



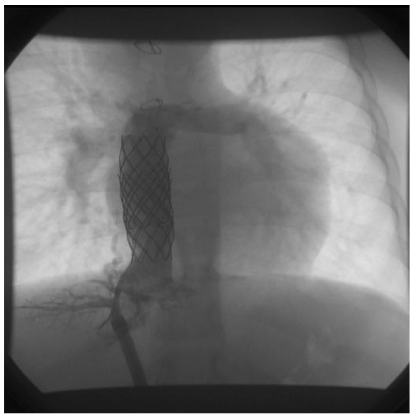
Pulsed wave Doppler interrogation of IVC in
patient 1 Showing Preservarion of respiratory
related variation of IVC flow.



Two-dimensional image of patient 1 illustrating the proximal part of Fontan
stent with less IVC dilatation.

Patient 2

An eight months old baby boy referred to KFSH&RC from another institution diagnosed as mesocardia ,DILV , l-malposed great arteries, PS and sub-PS. He had remarkable desaturation to 20s % therefore an urgent Glenn shunt was constituted on May10th.,2005 .An extracardiac Fontan was constructed on April 21st., 2008 using a contegra size 14 with augmentation of proximal LPA by bovine pericardium .Similar to patient 1 , aspirin was started after the Glenn shunt and warfarin was added after the Fontan .He has been regularly followed up at the outpatient clinic of KFSH&RC.

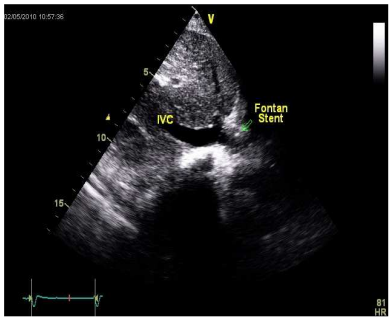


Stenting of EC Fontan contegra in patient 1
with angiography showing patency of Fontan pathways.

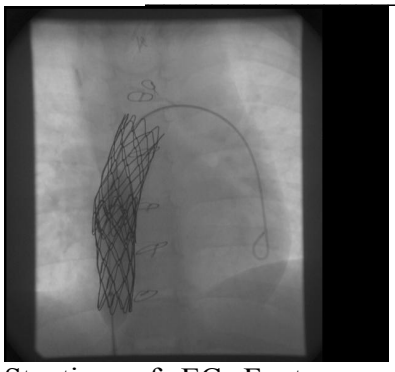
In one of his clinic visits he gave history of an episode of jaundice , dark urine & leg swelling dating one week prior to his visit diagnosed as hepatitis in another institution, on clinical examination, he was found to have an oxygen saturation of 95% , prominent superficial veins over the chest wall filling from below upwards with an otherwise unremarkable chest examination , grade 1/6 systolic ejection murmur , no hepatomegaly & no lower limb edema.

Echocardiography revealed reduced blood flow velocity in the IVC with prominent flow in a hemiazygous vein versus an abnormal venous channel. An urgent cardiac catheterization was arranged on April 11th. ,2009 to role out IVC obstruction and to delineate the venous anatomy .

Cardiac catheterization revealed an IVC mean pressure of 18 mmHg, SVC mean pressure of 20 mmHg. IVC angiograms showed totally obstructed Fontan contegra with blood clots , aneurysmal dilatation of the contegra and systemic venous drainge reaching the pulmonary circulation via dilated azygous & hemiazygous veins and multiple small collateral venous channels. Right internal jugular angiogram showed patent Glenn shunt & good size of RPA. The contegra was stented with 2 covered stents 45 x 8 mm and 39 x 8 mm dilated to 15 mm. After stenting, angiograms revealed good flow to LPA with a greater extent of flow to RPA as the stent was seen protruding into the LPA and directing the SVC flow to the RPA. Serial echocardiograms after stenting of the contegra showed patent Fontan connections . Shortly after stenting, a lung perfusion scan showed preferential flow to the right lung ; 86% compared with 14% for the left lung. Repeat lung perfusion scan 8 months later showed improved left lung perfusion ; 71% .



Two-dimensional image showing the proximal
part of of Fontan stent in patient 2



Stenting of EC Fontan contegra in patient 2
with balloon dilatation of the stent

Patient 3

This patient was first evaluated at KFSH&RC –Jeddah clinic at the age of 50 days . She had polysplenia with unbalanced AVSD, DORV ,VSD , PS & common atrium. Her mitral valve was atretic, ventricles were l-looped ,LV was hypoplastic & IVC was interrupted. A left bidirectional Kawashima shunt was constituted together with PAB at the age of 8 months.Three months later , cardiac catheterization revealed multiple large abdomino-pelvic veno-venous malformations (VVMs). Lung perfusion scan showed no pulmonary arterio-venous malformations (AVMs). ECG demonstrated atrial rhythm & sick sinus syndrome at the age of 6 years. Hepatic vein incorporation was performed at the age of 9 years using a fenestrated extra-cardiac Dacron tube size 18 mm to anastomose the hepatic vein confluence to the RPA. The MPA stump was suture closed. A 5 mm fenestration was constructed between the conduit and the atrium on the right because of the history of recurrent pleural effusion & chylothoraces. A permanent atrial & ventricular pacemaker leads were inserted due to presence of sick sinus syndrome & potential need for pacemaker in future Postoperative Echocardiography confirmed patent cavopulmonary connections & good ventricular functions .She was discharged home in a stable condition with an ECG showing a normal sinus rhythm fluctuating with an adequate junctional rate . In one of her follow up visits she had minimal bilateral pitting lower limb edema and mild abdominal distension. Echocardiography revealed thrombosis involving the lower part of the conduit. She was admitted to hospital with a normal INR as she missed two doses of her warfarin. However, by heparin infusion & resuming warfarin ,INR was readjusted to be therapeutic but worsening of thrombosis was detected by MRI. Lower limb edema progressed to be severe with development of ascites & bilateral pleural effusion. Several catheterization attempts failed to thrombectomize the hepatic veins and lower part of the conduit despite local streptokinase infusion into the clot using the transhepatic & transjugular approaches. Surgical intervention was made for hepatic vein thrombectomy and conduit replacement with a Gortex tube size 16 mm. A permanent pacemaker generator was inserted using the old AV permanent leads.

Patient 4

This patient had tricuspid atresia , pulmonary atresia, PDA .He underwent right BT shunt & PDA ligation then right bidirectional Glenn shunt followed by an extracardiac Fontan operation using a contegra size 18 mm. Two months following his Fontan operation . he developed mild respiratory distress , diminished air entry on the right side and hepatomegaly. Right pleural effusion was evident in chest x-ray. Sluggish flow across the Fontan was demonstrated by Echocardiography and a mild obstruction was suspected at the junction of Fontan tunnel to RPA.Cardiac catheterization confirmed the Echocardiogram findings. Streptokinase infusion was givenfor 24

hours followed by heparin infusion . The partial blockage of Fontan pathways improved as evidenced by Echo. & clinical examination in terms of increased flow velocity and reduction of liver size respectively.

It is of value to mention that the 4 patients who developed TE were kept on aspirin after their Glenn or Kawashima shunt , then after Fontan or hepatic vein incorporation ,warfarin was added for a target INR of 2 to 3 .

DISCUSSION

The potential advantages of the extracardiac Fontan procedure include avoidance of myocardial ischemia (aortic cross-clamping), atriotomy, and intra-atrial suture lines, as well as the feasibility of early or late fenestration. However, the capacity of this procedure to reduce late atrial arrhythmias and the longevity of the extracardiac conduit remain unproven (6–9).

Recently, the indications for the Fontan procedure have been extended to include more high-risk patients. An older age of patients was reported to be a risk factor for the Fontan procedure [10, 11], Ovroutski and coworkers [12] reported the clinical results of 15 Fontan completions with TCPC with an early mortality of 6.7% and a late mortality of 6.7%. The results of the current study were lower regarding early mortality ;3 %)probably due to younger age of our patients and comparable ; 7.6% concerning late mortality.The cause of an early death was cardiac tamponade due to bleeding, and the Fontan circulation itself could be established with stable hemodynamics before the cardiac tamponade. All of the patients in this study should be regarded as tolerant of the TCPC in the early postoperative period. The 5 late deaths occurred during the first 2 years after the TCPC. All of those patients were high risk patients with numerous risk factors. Although TCPC may be contraindicated for these high-risk patients, and orthotopic heart transplantation should have been considered the best option for these patients, they would have realistically almost no chance for heart transplantation in Kingdom of Saudi Arabia. Whether or not these 5 deaths were caused by the TCPC is unknown; however, it is obvious that the TCPC did not improve their late prognosis significantly. To improve quality of life and long-term prognosis, TCPC completion should therefore be performed as soon as possible once clearly indicated .

Twenty-one patients had at least 1 risk factor (range, 1 to 4). Early postoperative complications in this series comprised ascites 2 (3%) cases; prolonged pleural effusion 12 (18.4 %)cases; low cardiac output syndrome 4(6.1%) cases; significant postoperative bleeding 3 (4.6%) cases; acute renal failure 6 (9.2%) cases; and oxygen desaturation 4 (6.1%) cases; late postoperative complications took the form of new onset of PLE 6 (9.2%) cases; hepatic failure 1 (1.5%) case; worsening heart failure 5 (7.6%) cases; atrial tachyarrhythmias 5 (7.6%) cases; sick sinus syndrome 2 (3%) cases; and thrombosis 4 (6.1%)cases. The incidences of both early and late postoperative complications in this study are lower compared to those reported by others (20) probably due to larger number of younger patients with fewer risk factors in this study.

Eighty-nine percent of the patients in this series had no atrial tachyarrhythmia on late follow-up. The incidence of atrial tachyarrhythmia on late follow-up period in this study was lower than that of the previously reported TCPC studies, which mainly included an atriopulmonary connection [10, 13].

No criteria have yet been established for patients to undergo TCPC. It is reasonable to think that a careful and multidisciplinary risk analysis is the only way to determine the indications for this procedure. However, mean pulmonary artery pressure of 20 mm Hg or higher is presently the only contraindication to TCPC, not only for children but also for adults. We believe that the following criteria, namely, mean pulmonary vascular resistance of 4.0 wood units, and ejection fraction of 50% are usually acceptable. Although orthotopic heart transplantation is not a realistic choice in Kingdom of Saudi Arabia, this option should be considered for patients with severe systemic ventricular dysfunction that cannot be controlled by medication. Establishment of methods to accurately assess this patient population, such as the scoring of risk factors, is thus called for in future investigations.

The incidence of thrombosis after TCPC surgery has not yet been determined by prospective trials. Three cross sectional surveys used transesophageal echocardiography to assess the point prevalence of TE following Fontan surgery (3-5). The studies reported prevalences of 17, 20 and 33% respectively. All studies demonstrated an increased sensitivity with transoesophageal compared to transthoracic echocardiography. These studies highlight the importance of using the appropriate diagnostic test to determine the incidence of thrombosis in any population

The use of conduits, either intracardiac or extracardiac, obviate the need of tunneling and has excellent results in patients with normal inferior vena caval drainage. Long-term patency of these conduits continues to be excellent regardless of the material used—Gore-Tex, homograft tissue, or autologous pericardium(14). The longevity of the extracardiac conduit remains the most controversial aspect of this surgical option. The mechanism of late conduit obstruction is likely longitudinal torsion of the conduit during rapid somatic growth in height. The facility with which this obstruction can be treated by stent placement supports this mechanism (15).

The options for primary anti-thrombotic prophylaxis include routine prophylactic anticoagulation with warfarin or antiplatelet agents. Clearly, patients receiving warfarin will have higher probability of bleeding complications compared to those receiving aspirin. Australian data suggests that with a well coordinated pediatric anticoagulation clinic the annual risk of major bleeding in children on warfarin can be reduced to 0.05% per patient year. Warfarin requires regular monitoring which can have a significant impact on family life (16,17). Some reports raise the prospect of warfarin causing reduced bone density in children although further studies are required to confirm this effect (18). At this time there are no convincing data that any prophylactic antithrombotic regimen is effective in reducing TE. Thromboembolic events occur in patients receiving heparin, aspirin , or coumadin, as well as combinations or none of these.

CONCLUSION & RECOMMENDATION

TCPC could be offered to all candidates even if having multiple risk factors, with an acceptable mortality rate. Most of the TCPC candidates tolerated the procedure during the early postoperative period. However,the accumulation of risk factors may influence their late mortality. To improve the late clinical outcome for this

patient population, early TCPC is therefore required before complications occur.

Oral anticoagulation with dicumarol did not prevent conduit thrombosis at least in 4 of our patients. Nevertheless, it seems reasonable to recommend chronic oral anticoagulation with higher INR targets in those patients. The issue of anticoagulation therapy after TCPC procedure remains controversial (14,19). Further data are needed to either confirm or refute this opinion. Perhaps , a smaller diameter conduit should be used in these patients to prevent stagnation of blood predisposing to thrombosis (14).

The importance of careful ongoing evaluation of post-TCPC patients for thromboembolic events could not be over-emphasized.Clinically suspicious occurrences must be investigated in a timely fashion. This may include transesophageal echocardiography in circumstances in which there is an alteration from baseline hemodynamics.

The threshold for diagnostic and interventional cardiac catheterization should be lowered post-TCPC even in absence of echocardiographic evidence of IVC obstruction or lack of significant pressure gradient across contegral stenosis respectively.

In agreement with Igor et al (1), we do believe that unless multi-centre randomized trials are performed in the coming years, unwarranted adverse outcomes will continue to occur. The current uncertainty around the optimal primary prophylaxis regimes should be addressed to reduce the risk of thrombosis among children undergoing cardiac surgery in the future .

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