Journal of Cardiology & Diagnostics Research
JCDR, 2(2): 84-93
www.scitcentral.com
ISSN: 2639-4634
Original Research Article: Open Access

Post-Operative Assessment of Univentricular Repair by Multi-Slice Computed Tomographic Angiography

Ujjwal Kumar Chowdhury[1*], Lakshmi Kumari Sankhyan[1], Ashwani Kumar[1], Sandeep Seth[2], Priya Jagia[2] and Suruchi Hasija[3]

[*1]*Department of Cardiothoracic and Vascular Surgery, All India Institute of Medical Sciences, New Delhi, India*

[2]*Department of Cardiac Radiology, All India Institute of Medical Sciences, New Delhi, India*

[3]*Department of Cardiac Anesthesia, All India Institute of Medical Sciences, New Delhi, India.*

Received February 13, 2019; Accepted March 22, 2019; Published August 12, 2019

ABSTRACT

Background: The true incidence of cardiac thrombi, intra-tunnel thrombi and pulmonary thromboembolic events is unknown in patients undergoing total cavopulmonary connection (TCPC) for a functionally univentricular heart. No consensus is found in the literature regarding the tools for diagnosis of cardiac thrombi, intra-tunnel thrombi and pulmonary thromboembolism. This study used 16 slice-multi-slice Computerized Tomographic (MSCT) angiography in evaluating the diagnostic accuracy and incidence of these thromboembolic events.

Methods: Thirty-two patients with total cavopulmonary connections were evaluated with echocardiography and 16 slice-multi-slice CT angiography for thromboembolic events.

Results: A total number of 4 (12.5%) patients were detected to have thromboembolic complications through MSCT angiography. Out of which, only one (3.1%) patient was detected to have thrombus through echocardiography. Two (6.3%) out of 4 patients had asymptomatic segmental pulmonary embolism which was detected by MSCT angiography.

Conclusion: 16 slice-multi-slice CT angiography is an effective screening method to accurately diagnose the presence or absence of intra-and extra cardiac thrombus and asymptomatic silent pulmonary embolism after Fontan operation in order to optimize diagnostic and therapeutic strategies.

Keywords: Univentricular repair, Cavopulmonary connection, Multi-slice computed tomographic angiography, Intra-tunnel Thromboembolic events

INTRODUCTION

Despite improved survival and functional status of patients undergoing total cavopulmonary connection (TCPC), the pulmonary circulation remains anatomically abnormal and systemic ventricular function remains depressed, accounting for the current residual mortality and morbidity after this procedure [1,2]. Systemic venous hypertension, systemic and pulmonary venous obstruction, residual intracardiac right-to-left shunts, supraventricular arrhythmias, persistent ventricular dysfunction and thromboembolic events are the various causes of morbidity and mortality following Fontan operation [1,2]. Thrombosis of the Fontan pathway is often silent and may remain undetected until pathway obstruction results in significant elevation of venous pressures [3-6].

The true incidence of cardiac and intra-tunnel thrombi, pulmonary thromboembolism and systemic thromboembolic events is unknown [1-11]. Moreover, no consensus is found in the literature regarding the tools for diagnosis of cardiac and intra-tunnel thrombi and pulmonary thromboembolism [7-11].

Although echocardiography and angiography are the traditionally dominant imaging modalities, magnetic resonance imaging and computerized tomography are valuable non-invasive adjuncts.

Corresponding author: Dr. Ujjwal Kumar Chowdhury, Department of Cardiothoracic and Vascular Surgery, All India Institute of Medical Sciences, Ansari Nagar, New Delhi-110029, India, Tel: 91-11-26588700; Ext. 4835; Fax: 91-11-26588641; E-mail: ujjwalchow@rediffmail.com; ujjwalchowdhury@gmail.com

Citation: Chowdhury UK, Sankhyan LK, Kumar A, Jagia P & Hasija S. (2019) Post-Operative Assessment of Univentricular Repair by Multi-Slice Computed Tomographic Angiography. J Cardiol Diagn Res, 2(2): 84-93.

Doppler echocardiography is limited by a small field of view, a variable acoustic window, inability to penetrate air and bone, and difficulty in delineating extra cardiac vascular structures in their entirety. The interpretation of echocardiographic results is expertise dependent.

Cardiac catheterization and angiography is a traditional invasive imaging modality that yields important hemodynamic data and defines the vascular anatomy. But it is expensive. Patient is exposed to high doses of ionizing radiation and is limited by the risks inherent to iodinated contrast material wherein high doses of radio opaque dye is used as compared to CT angiography.

Magnetic resonance angiography plays a valuable role in this study especially the hemodynamic aspect. Although it is superior, limitations being expensive, not easily available in all centers, longer scanning times and it cannot be used in patients who have undergone preoperative/postoperative coil embolisation, artifacts, shunt take downs with metallic clips and patients with pacemaker device implanted [11,12]. Hence, CT angiography play a valuable role in bridging the gaps created by echocardiography, angiography and MR angiography in evaluation of patients who have previously undergone univentricular repair [5,13]. CT angiography has the advantage of easy availability and very short scanning time. It is less expensive and less invasive. Lower doses of ionizing radiations and radio-opaque dye are used as compared to conventional angiography and cardiac catheterization. With the advantage of direct multi-planar image reformation, multi-slice CT (MSCT) angiography has the benefits of improved diagnostic accuracy by detecting even peripheral pulmonary embolism at the sub-segmental arterial level even in patients with impaired respiratory function. To our knowledge however, there has been no systemic evaluation of usefulness of multi-slice computerized tomography angiography is demonstrating Fontan pathway. This prospective, non-randomized study was performed: i) To evaluate the occurrence of thrombotic obstruction of the Fontan pathway; ii) To diagnose silent thromboembolic events within both central and segmental pulmonary arterial pathways; iii) To determine the role of 16-slice multi-slice CT angiography in evaluating Fontan pathway obstruction; iv) To evaluate the sensitivity, specificity and predictive accuracy of CT findings; and, v) To identify the predisposing risk factors to optimize diagnostic and therapeutic strategies for patients after Fontan operation.

METHODS

Between January 1988 and June 2017, 660 patients underwent univentricular repair at All India Institute of Medical Sciences, New Delhi, India. This prospective study included 32 consecutive patients with univentricular repair who were seen for routine follow-up between April 2004 and June 2017 at our institution, who are either asymptomatic or in patients with suspected Fontan failure in the immediate postoperative period who were randomly selected. Informed consent was obtained from all participants.

Two basic modifications of univentricular repair were utilized and varied according to the preoperative anatomy. Modifications include an intra-atrial lateral tunnel fenestrated total cavopulmonary connection (LT-TCPC) and an extra cardiac polytetrafluoroethylene conduit TCPC (EC-TCPC).

Patient age, gender, operative details of the TCPC, NYHA functional class, current prescription medications, ECG, prothrombin time and complete two-dimensional transthoracic echocardiography and Doppler study (Hewlett-Packard Model 5500) performed in all patients. Systemic ventricular function was assessed qualitatively and graded 1 (Ejection fraction >0.60: Normal), 2 (Ejection fraction 0.40-0.60: Mild dysfunction) 3 (Ejection fraction 0.20-0.40: Moderate dysfunction) and 4 (Ejection fraction <0.20: Severe dysfunction) and the presence of cardiac; intra tunnel thrombi and pulmonary thromboembolism was recorded. A CT pulmonary angiogram was performed on a 16 slice-multi-slice CT scanner (Sensation 16, Siemens, Germany). The patient was placed in supine position with an 18 g cannula inserted into antecubital vein. A bolus tracking was performed keeping the region of interest over right and left pulmonary artery. A non-ionic contrast, Iohexol 65% (2 mg/kg) was injected at 2-2.5 cc/s. During breath hold, image acquisition was started automatically by the scanner once the peak of contrast in pulmonary artery reached 110 HU. This was then commenced from base of the neck to diaphragm.

The parameter for scanning include; slice thickness of 1 mm, rotation time of 0.42 s in a 11-12 s breath hold from base of neck to diaphragm with a table speed of 7.5 to 15 mm/s. Axial images were reconstructed to produce multi-planar reconstructions and oblique images as required. The volume of injected contrast agent, table speed and exposure factors varied with the patient body habitus. Soft copy images were interrogated using scroll mode on a dedicated computer by an experienced chest radiologist. The diagnosis of intra-tunnel thrombi, cardiac thrombi and pulmonary thromboembolism was made in accordance with published criteria.

STATISTICAL ANALYSIS

Statistical analysis was carried out using Stata 11.0 (College Station, Texas, USA). Continuous data were presented as mean ± standard deviation, whereas categorical variables were presented as frequency distribution and percentage. The p value of <0.05 was considered as statistically significant.

RESULTS

A total of 32 patients undergoing modified Fontan procedures were studied. The baseline characteristics of

patients are shown in **Table 1**. The age group of the study ranged from 4 to 30 years (mean 14.2 ± 6.4 years), 26 (81.3%) were males and 6 (18.7%) were females. The age at Fontan operation ranged from 2 to 28 years (mean 9.1 ± 5.7 years). The number of years since Fontan operation ranged from 1 month to 13 years (mean 5 ± 3.7 years). The underlying cardiac morphology was tricuspid atresia in 10 (31.3%) patients and non-tricuspid atresia type in 22 (68.7%) patients. The summary of cardiac morphology is shown in **Table 2**. Twenty-seven (84.4%) patients had undergone lateral tunnel fenestrated TCPC and 5 (15.6%) patients had undergone extra cardiac conduit TCPC. The individual patient characteristics are summarized in **Tables 2** and **3**. Twenty-eight (87.5%) patients were in NYHA functional class I, 2 (6.3%) were in class II, 1 (3.1%) in class III and 1 (3.1%) in class IV.

Table 1. Baseline patients characteristics of the study group (n=32).

Age (years), mean ± SD (range) at the time of investigation	14.2 ± 6.4 (4-30)
Sex	
Males	26 (81.3%)
Mean age at operation (years), mean ± SD(range)	9.1 ± 5.7 (2-28)
Mean period since operation (years)(range)	5 ± 3.7 (1 month-13 years)
Cardiac morphology	
Tricuspid atresia Non tricuspid atresia	10 (31.3%) 22 (68.7%)
Type of Fontan	
Lateral tunnel total cavopulmonary connection Extra cardiac total cavopulmonary connection	27 (84.4%) 5 (15.6%)

Table 2. Individual patient's characteristics of the study group.

No.	Age	Sex	Diagnosis	Procedure before Fontan	Type of Fontan operation	Age at Fontan operation (years)	Year since Fontan operation	NYHA class	Ventricular function	Arrhythmias	Medication	Location of thrombus
1	15	M	VSD, PS, Hypoplastic RV	-	Lateral tunnel TCPC	9	6	1	1	N	W+A	
2	7	F	DORV, VSD, PS	-	Lateral tunnel TCPC	3	4	1	1	N	W+A	
3	13	M	SI, Dextrocardia, VSD, PS, univentricular heart	Coil embolisation	Lateral tunnel TCPC	11	2	1	1	N	W+A	

4	10	M	TA, PA	-	Lateral tunnel TCPC	3	7	1	1	N	W + A	
5	16	M	SI, VSD, PS, univentricular heart	-	Lateral tunnel TCPC	9	7	1	1	N	W+A	
6	25	F	TA, VSD, PS	-	Lateral tunnel TCPC	22	3	2	2	N	W+A	Lt. LL PE
7	17	F	dTGA, TA, VSD, PS	-	Extra cardiac TCPC	15	2	1	1	N	W+A	
8	9	M	TA, VSD, PS	-	Lateral tunnel TCPC	3	6	1	1	N	W+A	
9	18	M	SS, Dextrocardia, TOF, hypoplastic RV	BD Glenn	Lateral tunnel TCPC	16	2	1	1	N	W+A	
10	8	M	dTGA, TA, VSD, PS	-	Lateral tunnel TCPC	7	1	4	4	N	W+A	RA, SVC, intra-tunnel RPA+LPA thrombus
11	23	M	TA, VSD, PS	RMBTS	Lateral tunnel TCPC	15	8	1	1	N	W+A	
12	20	M	DORV, VSD, PS	-	Lateral tunnel TCPC	9	11	1	1	N	W+A	
13	6	M	dTGA, VSD, PS	RMBTS	Lateral tunnel TCPC	4	2	1	1	N	W+A	

14	9	M	DORV, VSD, PS	-	Lateral tunnel TCPC	4	5	1	1	N	W+A	
15	16	M	TA, VSD, PS	-	Lateral tunnel TCPC	11	5	1	1	N	W+A	
16	11	M	VSD, PS, hypoplastic RV	BD Glenn	Lateral tunnel TCPC	10	1	1	1	N	W+A	
17	4	M	dTGA, VSD, PS	RMBTS	Lateral tunnel TCPC	3	1	1	1	N	W+A	
18	7	M	TA, VSD, PS	-	Extracardiac TCPC	5	2	1	1	N	W+A	
19	13	M	TA, VSD, PS, Juxtaposed atrial appendage	-	Extracardiac TCPC	12	1	1	1	N	W+A	
20	6	M	Univentricular heart, DILV, PS	-	Lateral tunnel TCPC	5	1	1	1	N	W+A	
21	7	F	VSD, PS, hypoplastic RV	RMBTS+BD Glenn	Extracardiac TCPC	7	1 month	3	3	N	W+A	IVC, RA, intra tunnel thrombus, Lt. LL PE
22	18	M	CCTGA, multiple muscular VSD	Coil embolisation	Extracardiac TCPC	10	8	1	1	N	W+A	
23	30	M	TA, VSD, PS	BD Glenn	Lateral tunnel TCPC	28	2	2	2	Intermittent CHB, PPI	W+A	Rt. LL PE
24	8	M	VSD, PS, hypoplastic RV	LMBTS	Lateral tunnel TCPC	6	2	1	1	N	W+A	

25	20	M	DORV, VSD, PS	-	Lateral tunnel TCPC	9	11	1	1	N	W+A	
26	12	M	dTGA, VSD, PS	BD Glenn	Lateral tunnel TCPC	4	8	1	1	N	W+A	
27	21	M	DORV, VSD, PS	-	Lateral tunnel TCPC	8	13	1	1	N	W+A	
28	20	F	Multiple muscular VSD, PS, hypoplastic RV	RMBTS+BD Glenn	Lateral tunnel TCPC	14	6	1	1	N	W+A	
29	21	M	SI, Dextrocardia, univentricular heart	LMBTS	Lateral tunnel TCPC	8	13	1	1	N	W+A	
30	11	M	TA, VSD, PS	-	Lateral tunnel TCPC	2	9	1	1	N	W+A	
31	13	M	TA, VSD, PS	-	Lateral tunnel TCPC	8	5	1	1	N	W+A	
32	20	F	TA, VSD, PS	-	Lateral tunnel TCPC	11	9	1	1	N	W+A	

BD Glenn: Bidirectional Glenn; CHB: Complete Heart Block; CCTGA: Corrected Transposition of the Great Arteries; DORV: Double Outlet Right Ventricle; IVC: Inferior Vena Cava; PS: Pulmonary Stenosis; PE: Pulmonary Embolism; LMBTS: Left Modified BT Shunt; LPA: Left Pulmonary Artery; LL: Lower Lobe; LMBTS: Left Modified BT Shunt; PPI: Permanent Pacemaker; PA: Pulmonary Atresia; TA: Tricuspid Atresia; RV: Right Ventricle; RPA: Right Pulmonary Artery; TCPC: Total Cavopulmonary Connection; W+A: Warfarin+Ecosprin; VSD: Ventricular Septal Defect

Table 3. Details of cardiac morphology of the study group.

S. No.	Cardiac morphology	No. of patients
1.	TA, VSD, PS	10 (31.3%)
2.	DORV, VSD, PS	5 (15.6%)
3.	VSD, PS, Hypoplastic RV	5 (15.6%)
4.	dTGA, VSD, PS	3 (9.4%)
5.	dTGA, TA, VSD, PS	2 (6.3%)
6.	Dextrocardia with univentricular heart	4 (12.5%)
7.	TA, PA	1 (3.1%)
8.	DILV, PS	1 (3.1%)
9.	Congenitally corrected TGA, multiple VSD	1 (3.1%)

TA: Tricuspid Atresia; VSD: Ventricular Septal Defect; PS: Pulmonary Stenosis; PA: Pulmonary Atresia; TGA: Transposition of Great Arteries; DILV: Double Inlet Left Ventricle; RV: Right Ventricle

Echocardiographically estimated ventricular function was normal in 28 (87.5%) patients, mild dysfunction in 2 (6.3%), moderate dysfunction in 1 (3.1%) and severe dysfunction in 1 (3.1%) patients. Thirty-one (96.9%) patients were in normal sinus rhythm. One (3.1%) patient had intermittent complete heart block, for which a permanent pacemaker implantation was done. All 32 (100%) patients were on low dose warfarin and aspirin according to our institute protocol.

There were 4 (12.5%) patients with thromboembolic complications. The characteristics of those patients with presence of thromboemboli are shown in **Table 4**. Out of 4 patients detected thromboembolism through MSCT angiography, one patient was detected of having thrombus by echocardiography (p=0.59). Two (6.3%) patients, who underwent operation at the age of 22 and 28 years (mean 25 years) had asymptomatic segmental pulmonary thromboembolism (PE) with mild ventricular dysfunction and 2 (6.3%) patients who had undergone operation at the age of 7 years had symptomatic right atrial intra-tunnel and pulmonary arterial thromboembolism with moderate to severe ventricular dysfunction.

Table 4. Characteristics of the patients with presence of thromboemboli (n=4).

Patient No.	Age (years)	Age at operation (years)	Type of operation	NYHA Class	Ventricular function	Detection of thrombi (Echocardiography)	Detection of thrombi (CT angiography)
6	25	22	LT-TCPC	II	2	-	Left lower lobe PE
10	8	7	LT-TCPC	IV	4	SVC, RA, intra-tunnel	RA, SVC, intra-tunnel, MPA, RPA, LPA
21	7	7	EC-TCPC	III	3	-	IVC, RA, Lt LL PE
23	30	28	LT-TCPC	II	2	-	Rt LL PE

EC-TCPC: Extracardiac Total Cavopulmonary Connection; IVC: Inferior Vena Cava; LL: Lower Lobe; LT-TCPC: Lateral Tunnel Total Cavopulmonary Connection; RA: Right Atrium; PE: Pulmonary Embolism; SVC: Superior Vena Cava

DISCUSSION

Physiologic correction accomplished with various modifications of the original Fontan procedure has improved survival and functional status of patients with a functionally univentricular heart. However, the pulmonary circulation remains anatomically abnormal and systemic ventricular function remains depressed, accounting for the current residual mortality and morbidity after this procedure [1,2,6]. Systemic venous hypertension, systemic and pulmonary venous obstruction, residual intra-cardiac-right-to-left shunts, supraventricular arrhythmias, intra-tunnel and intra cardiac thromboembolic occurrences and persistent systemic

ventricular dysfunction are the various causes of continuing morbidity and mortality following the Fontan procedure [1,2,6].

Central venous and intracardiac thrombosis is the major causes of morbidity and mortality after Fontan procedure. Shirai et al. [12] described a retrospective series of 16 patients undergoing extra cardiac Fontan procedures. The median follow-up was 13 months, and the incidence of intracardiac thrombosis was 19%. On the basis of these findings, the authors have begun routine antithrombotic prophylaxis with aspirin for 6 months after all Fontan procedures. The usefulness of such a protocol, as the authors point out, remains to be proven [12].

Prophylactic anticoagulation with warfarin or antiplatelet agents after Fontan procedures is frequently recommended [3,4,7]. However, no consensus is found in the literature or in routine clinical practice as to the optimal type or duration of anticoagulation. Consequently, a wide variety of prophylactic anticoagulant regimens are currently used.

The incidence of thromboembolism after Fontan procedures is the determining factor for appropriateness of prophylactic anticoagulation. Point prevalence for intracardiac thrombosis ranged from 17% to 20% in the cross-sectional survey. Reported incidences of venous thromboembolism and stroke ranged from 3% to 16% and 3% to 19%, respectively [3,4,7,10]. A number of authors have analyzed a variety of possible predisposing factors, including demographic and surgical factors (patient age at operation; type of Fontan procedure performed, including the presence or absence of fenestration; type of material used for the conduit; use of valved or non-valved conduits) and hemodynamic factors (arrhythmias, right-to-left shunts, polycythemia and low cardiac output). Although some studies claimed statistically significant relationships, predisposing risk factors were not identified with consistency or certainty. Consequently, no conclusions can be made about the relative contribution of patient demographic, surgical or hemodynamic factors in causing thromboembolism after Fontan procedures [7].

Coon et al. [3] investigated the frequency and location of thrombus in their population of children based on the type of Fontan operation performed. Between January 1987 and January 1999, 592 patients underwent echocardiography after Fontan operation and 52 (8.8%) had intracardiac thrombus. Median age at Fontan operation was 1.9 years (range 0.8 to 35.1). Thrombus was detected in the systemic venous atrium in 26 (48%) in the pulmonary venous atrium in 22 (44%), in both atria 1 (2%), in the hypoplastic left ventricular cavity in 2 (8%) and in the ligated pulmonary artery stump in 1 (2%).

In conclusion, thrombus formation occurs with equal frequency after atriopulmonary or lateral tunnel type Fontan modification, as well as in patients with or without fenestration. Thrombi are as commonly seen on the pulmonary venous side as they are on the systemic venous side and are usually adherent the baffle/patch separating the venous circulations. Their study lends support to the suggestion that thrombus formation after Fontan operation may be inherent to the physiology of cavopulmonary flow and not specifically related to the type of Fontan connection created or in patients on aspirin or warfarin [3].

Balling and colleagues reported that intracardiac thrombus is difficult to determine by means of routine transthoracic echocardiography. They evaluated in 52 patients the occurrence of intracardiac thrombi in different types of Fontan modifications as determined by transesophageal echocardiography. In 17 (33%) patients, thrombus formation could be found without clinical evidence of thromboembolic complications. Neither underlying morphologic disease nor age at operation, type of Fontan operation, sex, follow-up interval, arrhythmias or laboratory or hemodynamic findings could be identified as predisposing risk factors. They recommended routine transesophageal echocardiography to exclude eventual thrombi. Because of the high incidence of thrombi, they suggested oral anticoagulation therapy in all patients [4].

Verma et al. [8] studied the prevalence of pulmonary emboli (PE) in asymptomatic adult Fontan patients. Right atrial thrombi and systemic thromboembolic complications have been reported after the Fontan procedure. However, the frequency of silent pulmonary embolism (PE) in this patient population is not known. Thirty consecutive adult Fontan patients attending the adult congenital clinic over a six-month period underwent ventilation-perfusion (VQ) scanning and blood testing for thrombophilia tendency. If the VQ scan showed an intermediate or high probability for pulmonary embolism, a computerized tomography (CT) pulmonary angiogram was performed to confirm the presence of pulmonary embolism. Seventeen percent of adult patients with Fontan procedure have clinically silent pulmonary embolism. Pulmonary embolism were not present in any patients (30%) taking warfarin. Late age at the time of Fontan operation and type of Fontan anatomy were associated with increased risk of silent pulmonary embolism [8].

Helical and electron beam CT technology have made it possible to image the thorax in a short period of time, often during a single breath-hold. With these rapid scanning techniques, one can image a volume of tissue during peak contrast enhancement using only a moderate amount of intravenous contrast material. With good opacification of the pulmonary arteries, emboli within the vessels can be visualized in a relatively non-invasive manner [11-13]. In 1992 Remy-Jardin et al. [13] published the first prospective study comparing angiography with a helical CT examination tailored to visualize the pulmonary vessels. This and subsequent studies have confirmed that helical and electron beam CT are approximately 90% sensitive and 90% specific

for the evaluation of suspected pulmonary embolism to the level of the segmental or larger vessels. Many hospitals are using CT as a routine clinical tool for pulmonary emboli evaluation and Kuzo et al. [9] believe that CT has the potential to replace the ventilation perfusion scan for the diagnosis of pulmonary embolism in many clinical situations.

Bergin et al. [11] evaluated the accuracy of identification of central and segmental chronic pulmonary thromboembolic disease on helical computerized tomographic (CT) scans and on magnetic resonance (MR) images on 55 patients suspected of having chronic pulmonary thromboembolism. Central vessel disease was determined more accurately with helical CT scans (accuracy of 0.79 for each of the two readers) than with angiograms (accuracy of 0.74) or with MR images (accuracy of 0.39 and 0.46 for two readers). Segmental vessel disease was also more accurately determined with CT scans (accuracy of 0.75 and 0.76 for two readers) than with MR images (accuracy of 0.61 and 0.57 for two readers). They concluded that helical CT is a useful alternative to conventional angiography for diagnosis of chronic thromboembolism but may not be sufficient for selecting candidates for surgery in all cases [11]. In 2002 Remy-Jardin et al. [13] compared the impact of multi-slice CT (MSCT) angiogram with conventional helical single slice CT (SSCT) on image quality and diagnostic value in patients with pulmonary embolism with underlying respiratory disease and concluded that the benefits of MSCT were more marked for patients with underlying respiratory disease to detect even peripheral pulmonary embolism at sub-segmental arterial level and improvement in image quality on MSCT scans accounts for the improved diagnostic accuracy of CT angiography, in particular for patients with impaired respiratory function [13]. However, the utility of this technique in the patients operated with univentricular repair for assessment of thrombus and embolism has not been reported to the best of our knowledge.

In the present study, 16 slice multi-slice CT angiography showed presence of thrombus including at the segmental pulmonary arterial level in 4 (12.5%) patients as against echocardiography, which showed only one patient (3.1%) with right atrial and intra tunnel thrombus. MSCT angiography also showed 2 (6.3%) patients with asymptomatic segmental pulmonary embolism. A subset of patients undergoing various modifications of Fontan procedure will have failure of the previously functional Fontan circuit. Occult pulmonary embolism will cause increased pulmonary vascular resistance and silent Fontan pathway obstruction leading to disturbed flow dynamics and ventricular dysfunction. Hence there is a need to know the incidence of silent pulmonary thromboembolism. The only reported prevalence of silent pulmonary thromboembolism in the Fontan population was 17% and all these patients were not on anticoagulants.[8] In our study the prevalence of silent PE was 6.3% and all these patients were on anticogulant medication. In the previous study, the type of Fontan operations were more of atriopulmonary, Right atrial to right ventricle non-valved conduit and other complex conduit repairs of initial modifications.[8] Our study included only recent modifications of lateral tunnel fenestrated TCPC and extra cardiac conduit TCPC. Hence, the incidence of silent pulmonary embolism may be less in our study as compared to the previous study. But the overall incidence of thromboembolic complications was 12.5% which is comparable to other studies.

CONCLUSION

A 16 slice-multi-slice computerized tomographic angiography is an effective screening method to accurately diagnose the thromboembolic complications and silent pulmonary emboli after Fontan operation in order to optimize diagnostic and therapeutic strategies. However, these findings may form the basis for further study with larger study samples.

REFERENCES

1. Airan B, Sharrna R, Choudhary SK, Mohanty SR, Chowdhury UK, et al. (2000) Univentricular repair: Is routine fenestration justified? Ann Thorac Surg 69: 1900-1906.
2. Chowdhury UK, Airan B, Subramaniam G, Kothari SS, Saxena A, et al. (2005) Specific issues after extra cardiac Fontan operation at mid-term follow up. Systemic ventricular function, growth potential, arrhythmia and thromboembolism. Ann Thorac Surg 80: 665-672
3. Coon PD, Rychik J, Novello RT, Ro PS, Gaynor JW, et al. (2001) Thrombus formation after the Fontan operation. Ann Thorac Surg 71: 1990-1994.
4. Balling G, Vogt M, Kaemmerer H, Eicken A, Meisner H, et al. (2000) Intracardiac thrombus formation after Fontan operation. J Thoracic Cardiovasc Surg 119: 745-752.
5. Haramati LB, Glickstein JS, Issenberg HR, Haramati N, Croooke GA (2002) MR imaging and CT of vascular anomalies and connection in patients with congenital heart disease: Significance in surgical planning. Radiographics 22: 337-349.
6. Chowdhury UK, Mishra PK, Airan B, Sharma R, Subramaniam GK, et al. (2004) Postoperative assessment of the univentricular repair by dynamic radionuclide studies. Ann Thorac Surg 78: 658-665.
7. Monagle P, Cochrane A, McCrindle B, Benson L, Williams W, et al. (1998) Thromboembolic complications after Fontan procedure the role of prophylactic anticoagulation. J Thorac Cardiovasc Surg 115: 493-498.

8. Verma C, Warr MR, Hendler AL, Paul MS, Webb GD, et al. (2003) Prevalence of silent pulmonary emboli in adults after the Fontan operation. J Am Coll Cardiol 41: 2252-2258.

9. Kuzo RS, Goodman LR (1997) CT evaluation of pulmonary emboli: Technique and interpretation. Am J Roentgenol 169: 959-965.

10. Greaves SM, Hart EM, Brown K, Young DA, Batra P, et al. (1995) Pulmonary thromboembolism: Spectrum of clinical findings on CT. AJR Am J Roentgenal 165: 1359-1363.

11. Bergin CJ, Sirlin CB, Hauschildt JP, Huynh TV, Auger WR, et al. (1997) Chronic thromboembolism: Diagnosis with helical CT and MR imaging with angiographic and surgical correlation. Radiology 204: 695-702.

12. Shirai LK, Rosenthal DN, Reitz BA, Robbins RC, Dubin AM (1998) Arrhythmias and thromboembolic complications after the extra cardiac Fontan operation. J Thorac Cardiovasc Surg 115: 499-505.

13. Remy-Jardin M, Tillie-Leblond I, Szapiro D, Ghaye B, Cotte L, et al. (2002) CT angiography of pulmonary embolism in patients with underlying respiratory disease: impact of multi-slice CT on image quality and negative predictive value. Eur Radiol 12: 1971-1978.