

# The Impact of Multislice Computed Tomographic Angiography on the Diagnosis and Management of Congenital Heart Disease

Thesis for partial fulfillment of M.D degree in Cardiology

Submitted by
MOHAMED ABD EL-RAZIK GHAZY
M.B.B.Ch, M.Sc

Under supervision of

**Prof.Dr. Maiy Hamdy El-Sayed**Professor of Cardiology - Ain Shams University

Prof.Dr. Ghada Samir El-Shahed

Professor of Cardiology - Ain Shams University

**Dr. Hebatalla Mohamed Atia**Lecturer of Cardiology - Ain Shams University

Dr. Alaa Mahmoud Roushdy

Lecturer of Cardiology – Ain Shams University

Dr. Hasan El-Sayed Abd El-Monem

Radiodiagnosis department El-Galaa Military Family Hospital

Ain Shams University 2011

## **Index of Contents**

$\mathbf{T}$	•	O T	• 4	4
K	eview	At I	iters	atiire
1.		<b>\</b> /I I	/	

Congenital Heart Disease: Multimodality Imaging	1
-Echocardiography	2
- Cardiac catheterization	4
- Cardiac MRI	6
- MRI versus MSCT	10
Cardiac Multi-Slice CT	13
- Basic principles of MSCT	16
- Multislice CT system design	22
- Limitations and pitfalls with multi-slice CT	27
- Post-processing imaging modalities	28
- Clinical goals for cardiac and thoracic MSCT	31
- Technical aspects and imaging protocols for	
pediatric cardiac MSCT	34
CT Radiation Exposure: A public Health Issue	44
Congenital Heart Disease: CT Oriented Vascular And	
Anatomy and Management	55

Patients and Methods	108
Results	127
Discussion	180
<b>Conclusion and Recommendations</b>	193
Summary	194
References	198
Arabic Summary	

#### **List of Abbreviations**

**ADC** Analogue digital converter

**ALARA** As low as reasonably achievable

**ALCAPA** Anomalous Left Coronary Artery from Pulmonary Artery

**AS** Aortic Stenosis

**ASD** Atrial septal defect

**BEIR** Biological effect of ionized radiation

**CAT** Computed axial tomography

**CCA** Common Carotid Artery

**CHD** Congenital heart disease

**CMR** Cardiac magnetic resonance

**cMPR** Curved multiplanar reformatting

**CoA** Coarctation of Aorta

**CS** Coronary sinus

**CT** Computed tomography

**DLP** Dose length product

**DORV** Double Outlet Right Ventricle

**ECG** Electrocardiogram

**EMI** Electrical and Musical Industries

**EP** Electrophysiology

**FDA** Food and Drug Administration

**FOV** Field of view

**FSV** Functioning single ventricle

**Gy** Gray; radiation dose measurement unit

**HU** Housfield unit

**HLHS** Hypoplastic Left heart syndrome

**IAA** Interrupted aortic arch

**IEC** International electronical commission

IVC Inferior Vena Cava

**Kg** Kilogram

**kVp** Kilovolt potential

**LA** Left Atrium

**LPA** Left pulmonary artery

**LV** Left ventricle

**mA** Milliampere

MAPCA Major Aorto Pulmonary Collateral Artery

mAs Milliampere second

MBT Modified Blalok-Taussig

**MDCT** Multi detector row computed tomography

**MIP** Maximum intensity projection

**MPR** Multiplanar reformatting

MR Magnetic resonance

MRI Magnetic resonance imaging

**MSCT** Multi slice computed tomography

mSv MilliSievert; radiation dose measurement unit

**NSF** Nephrogenic systemic fibrosis

**PA** Pulmonary Artery

PAPVD Partial anomalous pulmonary venous drainage

**PAVM** Pulmonary Arterio-Venous malformation

**PDA** Patent Ductus Arteriosus

**PPG** Peak Pressure Gradient

**PS** Pulmonary stenosis

**RA** Right atrium

**RAA** Right aortic arch

**RPA** Right pulmonary artery

**RV** Right Ventricle

**SSFP** Steady state free precession

**SVC** Superior Vena Cava

**TAPVD** Total anomalous pulmonary venous drainage

**ToF** Tetralogy of Fallot

**UK** United Kingdom

**ULPV** Upper Left Pulmonary Vein

**US** United States

**VR** Volume rendering

**VSD** Ventricular septal defect

# **List of Figures**

Figure 1: Graph showing trends in cardiac imaging.	5
Figure 2: MRI bright blood image shows dilated RV.	8
Figure 3: Contrast MRI shows tight CoA.	9
Figure 4: Shared and unique features of MSCT and MRI.	11
Figure 5: Pediatric patients' selection for CT or MRI.	11
Figure 6: Diagram for CT scanners.	15
Figure 7: Modern MSCT machine.	16
Figure 8: CT machine from inside.	18
Figure 9: Moore's law for CT detectors.	19
Figure 10: Number of new CT slices at time of marketing.	20
Figure 11: Examples of fixed and adaptive detectors arrays.	24
Figure 12: Dual source CT system.	26
Figure 13: MSCT MPR oblique view shows the IVS.	28
Figure 14: Curved MPR image shows the RCA course.	29
Figure 15: MSCT MIP image of the RCA.	29
Figure 16: MSCT VR image of the chest wall.	30
Figure 17: Retrospective ECG triggered MSCT scanning.	40

Figure 18: Management Algorithm for PA anomalies.	56
Figure 19: Broncho-pulmonary segments.	57
Figure 20: MRI shows right MBT shunt.	62
Figure 21: MSCT angiography shows right MBT shunt.	62
Figure 22: MR angiography after different Fontan procedures.	69
Figure 23: MSCT VR image shows Glenn shunt.	70
Figure 24: Development of the aortic arch.	73
Figure 25: Coarctations of the aorta.	81
Figure 26: MSCT image shows aortic coarctation.	81
Figure 27: MRI VR image shows truncus arteriosus III.	87
Figure 28: MSCT axial image shows AP window.	89
Figure 29: MSCT VR image shows pulmonary sequestration	. 90
Figure 30: MSCT angiography of systemic venous anomalies	s. 96
Figure 31: MRI of bronchial sidedness in abnormal situs.	100
Figure 32: MSCT angiography of anomalous RCA origin.	102
Figure 33: anomalous origin of LCA.	103
Figure 34: MR angiography of unroofed CS post repair.	107
Figure 35: CT lightspeed VCT XT 64-detectors row scanner	. 113
Figure 36: Double barrel pump injector.	114

Figure 37: Sedated infant on the machine.	115
Figure 38: Injector touch screen.	117
Figure 39: Work station screen.	120
Figure 40: MSCT angiography shows subaortic VSD.	120
Figure 41: MSCT VR image of an abnormal aortic arch. 121	
Figure 42: MSCT MIP image of TAPVD.	122
Figure 43: A copy from patient radiation dose.	125
Figure 44: Gender distribution among study population. 127	
Figure 45: Distribution of cases according to scan target. 129	
Figure 46: Similarity between cardiac cathertization and MS	SCT
angiography in assessment of pulmonary artery.	
Figure 47: Superiority of MSCT over catheterization in	
assessment of MAPCA.	131
Figure 48: Comparison between MSCT and catheterization	
in assessment of left MBT shunt and RPA.	133
Figure 49: MSCT images shows patent PDA stent.	134

Figure 50: MS	CT shows occluded right external iliac arter	ry.
Figure 51: MS6 135	CT VR image shows LPA origin stenosis.	
Figure 52: MS	CT showing supravalvular AS.	141
Figure 53: Cha 143	rt representing arch anomalies within the st	tudy.
Figure 54: MSC	CT VR image shows tight CoA and hypoplastic arc	h 144
Figure 55: MSe 145	CT shows aortic interruption type B.	
Figure 56: MSo 145	CT of Aortic interruption type A and B.	
Figure 57: MS	CT of double aortic arch.	146
Figure 58: MSo 146	CT of double arch compressing the trachea.	
Figure 59: MS	CT of right aortic arch.	148
Figure 60: MS0 149	CT of right arch with aberrant left subclavian artery	<i>7</i> .
Figure 61: MS	CT of bovine arch and CoA.	149
Figure 62: MS6 150	CT of separate origin of left vertebral artery	<b>y.</b>
Figure 63: MS	CT of tight CoA and anterior collaterals.	153
Figure 64: MS	CT of preductal CoA.	153

Figure 65: MSCT of post operative aortic recoarctation. 154	
Figure 66: MSCT of post balloon aortic recoarctation. 155	
Figure 67: MSCT of post CoA stent.	156
Figure 68: MSCT of truncus arteriosus II and CoA.	159
Figure 69: MSCT axial image of a large AP window. 160.	
Figure 70: MSCT VR image of a large AP window.	160
Figure 71: MSCT of lung sequestration.	161
Figure 72: MSCT of normal pulmonary venous drainage. 164	
Figure 73: MSCT of polysplenia and PAPVD.	166
Figure 74: MSCT of TAPVD to CS.	167
Figure 75: MSCT of infracardiac TAPVD.	167
Figure 76: MSCT of supracardiac TAPVD.	168
Figure 77: MSCT of infracardiac PAPVD.	168
Figure 78: MSCT of left SVC.	170
Figure 79: MSCT of interrupted IVC and azygous continuation.171	
Figure 80: MSCT of Glenn shunts.	171

Figure 81: MSCT of the spleen in different situs. 173

### **List of Tables**

Table 1:	Capacity of imaging modalities in assessment of congenital heart disease.	6
Table 2:	CT chest scan protocols for different CT generations.	22
Table 3:	Different coefficient factors for conversion between absorbed and effective radiation.	46
Table 4:	Radiation doses in different radiological examinations	47
Table 5:	ESC recommendations 2010 for interventions for coarctation of aorta	83
Table 6:	Amount of contrast material Adjusted to body weight	114
Table 7:	Distribution of cases according to age	128
Table 8:	Distribution of cases according to body weight	128
Table 9:	Reasons for MDCT referral.	129
Table 10:	The echocardiographic diagnoses of group I.	130
Table 11:	MDCT main pulmonary arterial abnormalities among group I.	132
Table 12:	Associated arch anomalies in group I	136

Table 13:	Comparison between the cardiac catheterization and MDCT findings in group I.	138
Table 14:	Additional MDCT findings regarding the assessment of PA confluence by echocardiography	139
<u>Table 15:</u>	Primary diagnoses of patients in group II.	140
Table 16:	Comparison between aortic arch echocardiographic and MDCT angiographic findings among the study population	142
<u>Table 17:</u>	Abnormal aortic arch sidedness and vessels arrangement	147
Table 18:	Comparison between echocardigraphic and MDCT angiographic findings regarding aortic coarctation.	151
Table 19:	Distribution of the native aortic coarctation according to MDCT findings	152
Table 20:	Primary diagnoses of patients with aorto- pulmonary connections.	158
Table 21:	Cases of lung sequestration	161
Table 22:	Distribution of PDA among patients with CHD who were referred for MDCT	162
Table 23:	Distribution of the patients having anomalous pulmonary venous drainage	164