Real Time 3D Echocardiography for Evaluation of TOF Cases as an Alternative to Cardiac Catheterization

Thesis

Submitted in partial fulfillment of the MD Degree
in Cardiology

By

Ahmed Mounir Gabr
(M.B.B.CH) – MSc. Cardiology

Under Supervision of

Prof. Maiy Hamdy El-Sayed
Professor of Cardiology
Faculty of Medicine – Ain Shams University

Prof. Azza Abdallah El-Fiky
Professor of Cardiology
Faculty of Medicine – Ain Shams University

Prof. Ghada Samir El-Shahed
Professor of Cardiology
Faculty of Medicine – Ain Shams University

Dr. Hebatallah Mohamed Attia
Assistant Professor of Cardiology
Faculty of Medicine – Ain Shams University

Dr. Alaa Mahmoud Roshdy
Assistant Professor of Cardiology
Faculty of Medicine – Ain Shams University

Faculty of Medicine
Ain Shams University
Cairo – 2014

Acknowledgements

First of all, thanks to ***ALLAH,*** by grace and mercy of whom the accomplishment of this work was done.

I wish to express my deepest gratitude to **Prof. Maiy Hamdy El-Sayed,** Professor of Cardiology, Faculty of Medicine – Ain Shams University, for her generous supervision and directions, I really has the honor to complete this work under her supervision.

My great appreciation and sincere gratitude to **Prof. Azza Abdallah El-Fiky,** Professor of Cardiology, Faculty of Medicine – Ain Shams University, for her generous guidance and support during the scope of this work.

I am sincerely grateful and thankful to **Prof. Ghada Samir El-Shahed,** Professor of Cardiology, Faculty of Medicine – Ain Shams University, for her great supervision, valuable advice and unlimited help to provide all facilities to accomplish this work.

I am sincerely grateful and thankful to **Dr. Hebatallah Mohamed Attia,** Assistant Professor of Cardiology, Faculty of Medicine – Ain Shams University, for her keen interest, encouragement and helping me in the whole thesis.

Last but not least, I can't forget to thank with all appreciation **Dr. Alaa Mahmoud Roshdy,** Assistant Professor of Cardiology, Faculty of Medicine – Ain Shams University, for his great efforts and time he has devoted to accomplish this work.

Ahmed Mounir Gabr

Contents

List of Abbreviations

AO : Aorta.

ASD : Atrial septal defect

AV : Atrioventricular

AVSD : Atrioventricular septal defect

BTS : Blalock Taussing shunt

CAVV : Common Atrioventricular valve

CHD : Congenital heart disease

CMR : Cardiac Magnetic resonant imaging

DORV : Double outlet right ventricle

EF : Ejection fraction

INN : Innominate

IVS : Interventricular septum

LA : Left atrium

LAA : Left atrial appendage

LV : Left ventricle

LPA : Left pulmonary artery

MPR : Multiplaner reformating

MR : Mitral regurgitation

MVA : Mitral valve area

PDA : Patent ductus arteriosus

PFO : Patent foramen ovale

List of Abbreviations *(Cont...)*

PS : Pulmonary stenosis

PV : Pulmonary valve

RPA : Right pulmonary artery

RV : Right ventricle

RVOT : Right ventricular outflow tract

RT3DE : Real time 3 dimensional echocardiography

STIC : Spatio-temporal imaging correlation

SVC : Superior vena cava

TEE : Transesophgeal echo

TGA : Transposition of great vessels

TOF : Tetralogy of Fallot

TV : Tricuspid valve

2DE : 2 Dimensional echocardiography

3DE : 3 Dimensional echocardiography

List of Tables

List of Figures

List of Figures *(Cont...)*

List of Figures *(Cont...)*

Introduction

Tetralogy of Fallot occurs in 10% of all congenital heart disease, and is the most common cyanotic heart defect seen in children and beyond infancy ***(Park, 20008).***

Cardiac catheterization is done in patient with tetralogy of Fallot preoperatively, to delineate the coronary anatomy, aortopulmonary collaterals, presence and course of pulmonary blood vessels, and exclusion of other associated cardiac anomalies (as right aortic arch in 25% of cases) ***(Douglas et al., 2005).***

Cardiac catheterization, helds a lot of complications apart from the financial burden, which includes: DVT, tachyarrythmias, etc ***(Park et al., 2008).***

Real time 3D echocardiography

A number of innovative advances have occurred in pediatric echocardiography including utilization of harmonics to improve border detection, contrast agents to enhance chamber imaging and Doppler interrogation of jets, and Doppler tissue velocimetry to glean an enhanced understanding of both ventricular function ***(Gerald, 2003).***

However, a most recent advance, which has also has important application for day to day clinical care, is real-time three-dimensional (3-D) echocardiography ***(Gerald, 2003).***

In November of 2002, live 3D imaging, an advanced form of real-time 3D imaging, was introduced by Philips Medical Systems. The major advance that this latest version of real-time 3D imaging immediately offered was improved image quality due to a fully sampled or dense array configuration of the transducer, called a matrix array.

As the term implies, "real-time" 3D imaging takes place on the fly, with reconstruction performed simultaneously with imaging via a personal computer on the sonography machine ***(Houck et al., 2006).***

Studies have shown, in both in-vitro, in-vivo and human clinical studies the advantages of the 3-D echocardiography over two-dimensional (2-D) echocardiography for ventricular volumes, mass and ejection fraction calculations ***(Altman et al., 1997).***

The potential for real time three-dimensional echocardiography seem unbounded in the display and understanding of acquired and congenital heart disease ***(Gerald, 2003).***

Aim of the Work

The aim of the present work is to:

1. Evaluate real time 3D echocardiography in the preoperative assessment of patients with tetralogy of Fallot.

2. Assess the impact of real time 3D echocardiography in decreasing the number of preoperative cardiac catheterization procedures.

Chapter (1)
Tetralogy of Fallot

Tetralogy of Fallot is a cyanotic congenital heart malformation comprising infundibular pulmonary stenosis, a conoventricular septal defect, dextroposition of the aorta such that the aortic root overrides the crest of ventricular septum, and right ventricular hypertrophy **(Fig 1)**.

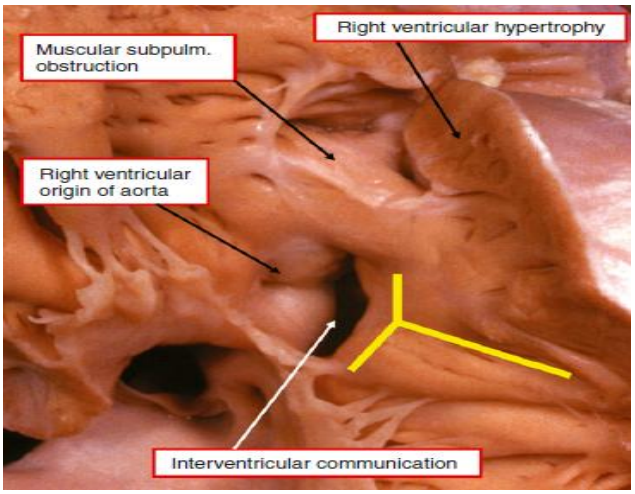

Fig. (1): As was emphasized by Arthur Louis Etienne Fallot, as long ago as 1888, all cases have an interventricular communication, biventricular origin of the aorta, muscular obstruction within the right ventricular outflow tract, and right ventricular hypertrophy ***(Anderson et al., 2010)*.**

In 1888 Arthur Etienne Fallot separated the malformation that is now described with his name from other anatomic lesions responsible for the "Maladie bleue", although autopsy cases had been recognized previously; Dr Fallot was

the first to correlate clinical features with pathological findings ***(Anderson et al., 2010).***

More than three decades ago **Van Praagh and his colleagues** in 2009 suggested that tetralogy of Fallot is really a monology of Fallot resulting from the displacement of the infundibular or outlet septum and that in tetralogy the outlet septum is "too short, too narrow, too shallow ". The malalignment of the infundibular septum is considered now the essence of tetralogy of Fallot.

The leftward or septal end of infundibular septum is displaced anteriorly, inserting into the left anterior division of the septal band rather than between its two divisions in the normal heart. The rightward of the infundibular septum is rotated anteriorly and passed anteriorly and superiorly to reach the free wall of the right ventricle, so that the infundibular septum and its parietal extension lie almost in sagital plane rather than the usual frontal plane, so it is called anterior and cephalad deviation of infundibulum septum ***(Yoo et al., 2004).***

Twenty five percent of patients with tetralogy of Fallot will have right aortic arch. In the patients with right aortic arch and an aberrant left subclavian artery, the anomalous subclavian artery almost always originates directly from the descending aorta; it can also be isolated from its normal aortic arch origin, having instead its origin from the left

pulmonary artery. With closure of the left arterial duct the left subclavian artery will be isolated, filling from a left vertebral and subclavian steel ***(Anderson, 1991).***

Bilateral arterial ductus have been diagnosed in patients with tetralogy of Fallot. Rarely coarctation of the aorta or interruption of the aortic arch has been described.

Coronary artery anomalies assume importance in tetralogy of Fallot because of their potential for damage and interruption at the time of right venticulotomy. The most common important abnormality complicating repair of tetralogy of Fallot is origin of left anterior descending artery from right coronary artery occurring in about 5% of patients. In this situation the anterior descending artery crosses the right ventricular outflow tract a variable distance from the pulmonary valve ***(Yoo et al., 2004).***

Tetrallogy of Fallot is listed as a "rare disease" by the Office of Rare Diseases (ORD) of the National Institutes of Health (NIH). This means that Tetralogy of Fallot, or a subtype of Tetralogy of Fallot, affects less than 200,000 people in the US population.

Ophanet, who are a consortium of European partners, currently defines a condition rare when it affects 1 person per 2,000. They list Tetralogy of Fallot as a "rare disease" ***(Bailliard and Anderson, 2009).***