

**Evaluation of Myocardial Contraction Fraction as
an Echocardiographic Predictor of Functional
Capacity in Patients with Heart Failure with
Reduced Ejection Fraction**

Thesis

*Submitted for Partial Fulfillment of Master
Degree of Cardiology*

By

Hassan Ahmed Addow

M.B.B.Ch, University of Science and Technology- Yemen

Under Supervision of

Prof. Dr. Ramy Raymond Elias

*Assistant Professor of Cardiology-Cardiology Department
Faculty of Medicine – Ain Shams University-Egypt*

Dr. Yasser Alaa Eldin Mahmoud

*Lecturer of Cardiology-Cardiology Department
Faculty of Medicine – Ain Shams University-Egypt*

Faculty of Medicine
Ain Shams University

2017

تقييم النسبة الانقباضية لعضلة القلب بالموجات فوق الصوتية كمؤشر تنبؤى لقدرة الوظيفية في المرضى الذين يعانون من ضعف عضلة القلب

رسالة

توطئة للحصول على درجة الماجستير في أمراض القلب

مقدمة من

الطبيب / حسن أحمد عدو

بكالوريوس الطب والجراحة - جامعة العلوم والتكنولوجيا - اليمن

تحت إشراف

أ.د / رامي ريمون إلياس

أستاذ مساعد - أمراض القلب والأوعية الدموية

كلية الطب - جامعة عين شمس

دكتور / ياسر علاء الدين محمود

مدرس أمراض القلب والأوعية الدموية

كلية الطب - جامعة عين شمس

كلية الطب

جامعة عين شمس

2017

Acknowledgment

*First and foremost, I feel always indebted to **ALLAH**, the Most Kind and Most Merciful.*

*I'd like to express my respectful thanks and profound gratitude to **Prof. Dr. Ramy Raymond Elias**, Assistant Professor of Cardiology-Cardiology Department Faculty of Medicine, Ain Shams University, Egypt, for his keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work.*

*I am also delighted to express my deepest gratitude and thanks to **Dr. Yasser Alaa Eldin Mahmoud**, Lecturer of Cardiology-Cardiology Department, Faculty of Medicine, Ain Shams University, Egypt, for his kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work.*

I would like to express my hearty thanks to all my family for their support till this work was completed.

Last but not least my sincere thanks and appreciation to all patients who participated in this study.

Hassan Ahmed Addow

List of Contents

| Title | Page No. |
|---|----------|
| List of Tables | i |
| List of Figures | iii |
| List of Abbreviations | vii |
| Introduction | 1 |
| Aim of the Work..... | 4 |
| Review of Literature | |
| ▪ Etiology of Heart failure and Pathophysiology | 5 |
| ▪ Symptoms and signs | 11 |
| ▪ Functional Capacity in Heart Failure | 21 |
| ▪ Three-dimensional Echocardiography | 30 |
| Subjects and Methods | 41 |
| Results | 64 |
| Discussion | 100 |
| Study Limitations | 107 |
| Summary | 108 |
| Conclusion and Recommendation..... | 110 |
| References | 111 |
| Master Table | 134 |
| Arabic Summary | |

List of Tables

| Table No. | Title | Page No. |
|--------------------|--|----------|
| Table (1): | The etiology of HF | 7 |
| Table (2): | Definition of heart failure with preserved (HFpEF), mid-range (HFmrEF) and reduced ejection fraction (HFrEF) | 9 |
| Table (3): | NYHA functional classification..... | 10 |
| Table (4): | The ACC/AHA stages of heart failure | 10 |
| Table (5): | Symptoms and signs of heart failure | 12 |
| Table (6): | The BORG scale..... | 47 |
| Table (7): | Comparison of demographic data and risk factors between Cases (HF) and control (Normal) | 65 |
| Table (8): | Comparison of two dimensional Echocardiographic Parameters between Cases (HF) and control | 67 |
| Table (9): | Shows that there is a statistically significant higher degree of mitral and Tricuspid valve regurgitation in HF patients than in control group ($P < 0.001$, $P = 0.007$) respectively..... | 69 |
| Table (10): | Comparison of 3D-Echocardiographic Parameters between Cases and control | 71 |
| Table (11): | Shows that there is a highly statistically significant difference between HF group and control group as regard their MCF | 72 |
| Table (12): | Shows statistically significantly difference between MCF, NYHA functional class, demographic data, risk factors and clinical parameters..... | 74 |
| Table (13): | Shows correlation between MCF Minnesota score, 6min d in meter age, BSA and BMI | 75 |
| Table (14): | Correlation between MCF and echocardiographic parameters | 77 |

List of Tables (cont...)

| Table No. | Title | Page No. |
|--------------------|--|----------|
| Table (15): | Shows relation NYHA class with demographic data and echocardiographic parameters..... | 79 |
| Table (16): | Relation a minnesota score with demographic data, echocardiographic parameters..... | 81 |
| Table (17): | Shows correlation between MLFQ and echocardiography parameters | 84 |
| Table (18): | Shows that there is a significant relation between Minnesota and higher degree of PR and TR (p=0.012, 0.003 respectively)..... | 87 |
| Table (19): | Shows correlation between 6MWT, age, BMI and BSA | 88 |
| Table (20): | Shows correlation between 6MWT with echocardiographic parameters | 89 |
| Table (21): | Correlation between 2D echo parameters with 3D echo parameters..... | 91 |
| Table (22): | Linear regression analysis for 6MWD | 92 |
| Table (23): | Shows classification of 6MWD into group A & Group B | 93 |
| Table (24): | Comparison between both groups as regards demographic data & risk factor | 95 |
| Table (25): | Comparison between both groups, as regards echo cardio graphic parameters | 96 |
| Table (26): | Comparison between both groups as regards valvular regurgitation..... | 97 |
| Table (27): | A Cut-off Value of Myocardial contraction Fractional (MCF) Shortening and between both groups | 99 |

List of Figures

| Fig. No. | Title | Page No. |
|---------------------|--|----------|
| Figure (1): | Activation of neurohormonal systems in heart failure | 14 |
| Figure (2): | Effects of sympathetic nervous system activation | 15 |
| Figure (3): | Cardiac and cellular remodeling in response to haemodynamic overloading | 18 |
| Figure (4): | Patterns of LV Remodeling based on EDV | 20 |
| Figure (5): | Minnesota living with heart failure questionnaire (MLHFQ) | 24 |
| Figure (6): | Cardiopulmonary exercise testing. | 25 |
| Figure (7): | Examples of Three-Dimensional Echocardiographic Analysis Using Mesh and Slices. | 32 |
| Figure (8): | The measurement of aortic valve area by three-dimensional trans esophageal echocardiography | 36 |
| Figure (9): | Assessment of the relationship of the left and right coronary artery ostia..... | 37 |
| Figure (10): | Elliptically-shaped atrial septal defect (a) before and (b) after closure with umbrella device | 39 |
| Figure (11): | Two-dimensional guided M mode echocardiogram of the LV in parasternal short axis view at papillary muscle level | 51 |
| Figure (12): | Measurement of left atrial diameter (LAD) from M-mode at level of aortic valve | 52 |
| Figure (13): | Two dimensional measurements for ejection fraction calculation using the biplane method of discs (modified Simpson rule) in apical four-chamber at end diastole and end systole..... | 53 |

List of Figures (cont...)

| Fig. No. | Title | Page No. |
|---------------------|---|----------|
| Figure (14): | Left panel shows pulsed wave Doppler of mitral inflow with sample volume at mitral leaflets tips in a normal patient..... | 54 |
| Figure (15): | Measurements of left atrial volume from the biplane method of discs | 55 |
| Figure (16): | Measurement of tricuspid annular plane systolic excursion..... | 56 |
| Figure (17): | Apical 4chamber view showing multislice acquisition ⁽¹¹⁷⁾ | 57 |
| Figure (18): | Shows 4D Auto LVQ..... | 58 |
| Figure (19): | Apical 4chamber view showing alignment..... | 58 |
| Figure (20): | Apical view showing one point at mid-basal area and one point at the apex..... | 59 |
| Figure (21): | Volume waveform displaying m EDV, ESV, EF, HR, SV, CO, SV and SPI..... | 60 |
| Figure (22): | Volume curve showing relation EDV with ESV. | 61 |
| Figure (23): | Displaying results 4D LV Mass..... | 61 |
| Figure (24): | Shows a comparison of EF (M-m, 2D) between Cases (HF) and control (P<0.001)..... | 68 |
| Figure (25): | Shows a comparison of E/e', SPAP (P<0.001) TAPSE (P=0.028) between Cases and control. | 68 |
| Figure (26): | Shows a comparison of MR between Cases (HF) and control (P<0.001). | 70 |
| Figure (27): | Shows a comparison of TR between Cases (HF) and control (P=0.007). | 70 |
| Figure (28): | Shows a comparison of LV mass index (2D, 3D), LV Mass-3D between Cases (HF) and control (P<0.001). | 72 |

List of Figures (cont...)

| Fig. No. | Title | Page No. |
|---------------------|---|----------|
| Figure (29): | Shows a comparison of MCF between Cases and control P (< 0.001)..... | 73 |
| Figure (30): | A plot chart shows a significant negative correlation between MCF and Minnesota score. | 75 |
| Figure (31): | A plot chart shows a significant positive correlation between MCF and 6min d in meter..... | 76 |
| Figure (32): | Relation between Minnesota score and IHD non IHD..... | 82 |
| Figure (33): | Relation between Minnesota score NYHA functional class. | 82 |
| Figure (34): | A plot chart shows a significant negative correlation between Minnesota score and 6min d in meter. | 85 |
| Figure (35): | A plot chart shows a significant positive correlation between Minnesota score, and LVMI..... | 85 |
| Figure (36): | A plot chart shows a significant positive correlation between Minnesota score, and LV mass..... | 86 |
| Figure (37): | A plot chart shows a significant positive correlation between Minnesota score and LVI 3D..... | 86 |
| Figure (38): | Show a significant relation between Minnesota and TR. | 87 |
| Figure (39): | Shows a significant relation between Minnesota and PR. | 88 |
| Figure (40): | A plot chart shows a significant negative correlation between 6MWTD and LV Mass..... | 90 |

List of Figures (cont...)

| Fig. No. | Title | Page No. |
|---------------------|--|----------|
| Figure (41): | A plot chart shows a significant negative correlation between 6MWTD and LV MI. | 90 |
| Figure (42): | Pie chart shows comparison between patients who walked less than and more than 300M..... | 94 |
| Figure (43): | Shows a significant positive relation between 6min d in meter and MR..... | 98 |
| Figure (44): | Cut-off Value of Myocardial contraction Fractional (MCF) Shortening and between Group a Subjects and Group. | 99 |

List of Abbreviations

| Abb. | Full term |
|---------------|--|
| 2D..... | Two dimensional |
| 3D..... | Three dimensional |
| 3D-STE | Three-dimensional speckle-tracking echocardiography |
| 3DTOE..... | Three Dimensional Trans esophageal Echocardiography |
| 6MWD..... | 6-minute walk test duration |
| 6MWT | Six minute walk test |
| ACC/AHA | American College of cardiology |
| ACE..... | Angiotensin converting enzyme |
| AF | Atrial fibrillation |
| AIDS | Acquired immunodeficiency syndrome |
| ARVC | Arrhythmogenic right ventricular cardiomyopathy |
| ASE..... | American Society of Echocardiography |
| BMI..... | Body Mass index |
| BSA..... | Body surface area |
| CAD | Coronary artery disease |
| CNS..... | Central nervous system |
| CO | Cardiac out put |
| COPD..... | Chronic obstructive pulmonary disease |
| CPET | Cardiopulmonary exercise testing |
| CRT..... | Cardiac resynchronization therapy |
| DBP..... | Diastolic blood pressure |
| DC | Direct Cardio version |
| DCM..... | Dilated cardiomyopathy |
| DM | Diabetes mellitus |
| E..... | Early diastolic velocity wave |

List of Abbreviations (Cont...)

| Abb. | Full term |
|-------------|--|
| E/A | Ratio between early diastolic wave amplitude of annulus movement and late diastolic wave amplitude of annulus movement |
| ECG | Electrocardiogram |
| EDV | End Diastolic volume |
| EF | Ejection fraction |
| ESV | End Systolic volume |
| HCM | Hypertrophic cardiomyopathy |
| HF | Heart failure |
| HFpEF | Heart failure preserved ejection fraction |
| HFREF | Heart failure reduced ejection fraction |
| HIV | Human immunodeficiency virus |
| HmrEF | Heart failure mid-range ejection fraction |
| HR | Heart rate |
| HRQOL | Health related Quality of life |
| HTN | Hypertension |
| ICD | Intracardiac defibrillator |
| IHD | Ischemic heart disease |
| IVS | Interventricular septum |
| LA | Left atrium |
| LAA | Left atrial appendage |
| LDL | Low density lipoprotein |
| LV | Left ventricle |
| LVH | Left ventricular hypertrophy |
| LVM | Left ventricular mass |
| MA | Mitral annulus |
| MCF | Myocardial contraction fraction |
| METS | Metabolic equivalents |
| Min | Minute |

List of Abbreviations (Cont...)

| Abb. | Full term |
|------------------------|---|
| ml/kg/min | Milliliters per kilogram per minute |
| MLHFQ | Minnesota Living with Heart failure Questionnaire |
| mm | Millimeter |
| mmHg | Millimeter mercury |
| MR | Mitral regurgitation |
| NYHA | New York Heart Association Functional |
| PR | Pulmonary regurgitation |
| PW | Posterior wall |
| RA | Right atrium |
| RAAS | Renin angiotensin converting enzyme Aldosterone system |
| RT3DE | Real time three dimension echocardiography |
| RT4DE | Real time four dimension echocardiography |
| RVSP..... | Right ventricular systolic pressure |
| RWT..... | Relative Wall Thickness |
| SBP | Systolic Blood pressure |
| SD | Standard deviation |
| Sec..... | Second |
| SPAP..... | Systolic pulmonary artery pressure |
| SPSS | Statistical package for social science |
| SV..... | Stroke volume |
| TAPSE | Tricuspid Annular Plane Systolic Excursion |
| TDI..... | Tissue Doppler image |
| TR | Tricuspid Regurgitation |
| VCO ₂ | Rate of elimination of Carbon Dioxide |
| VE | Ventilator equivalent |
| VT | Ventilator threshold |
| βAR | β-adrenergic receptor |

ABSTRACT

NYHA classification. Each patient performed a 6MWT and complete a forum of MLHFQ, offered an ECG gated echocardiographic study for assessment of systolic and diastolic functions of right & left ventricles.

Calculated MCF from the HF patients was compared with that obtained from 30 healthy subjects (Group A).

The goal of the study was to determine the correlation between myocardial contraction fractions (MCF), and functional status assessed by 6MWD & quality of life assessed by MLHFQ in HF patients NYHA class I – III.

Keywords: Right ventricular systolic pressure - Renin angiotensin converting enzyme Aldosterone system - Ischemic heart disease - Heart rate .

INTRODUCTION

Hear failure (HF) is a complex clinical syndrome that results from any structural or functional cardiac disorder that impairs the ability of the ventricle to fill with or eject blood ⁽¹⁾. HF is a global pandemic affecting an estimated 26 million people worldwide and resulting in more than one million hospitalizations annually. Although the outcomes for ambulatory HF patients with a reduced ejection fraction (EF) have improved with the discovery of multiple evidence-based drug and device therapies, hospitalized HF patients continue to experience unacceptably high post-discharge mortality and readmission rates that have not changed in the last 2 decades ⁽²⁾.

Functional capacity is considered to be an important clinical and prognostic measure in patients with HF ⁽³⁾. The 6-minute walk test (6MWT) has classically been used in clinical settings to evaluate exercise capacity at submaximal exercise levels and has been shown to be an independent predictor of mortality and hospitalizations in patients with HF and a sensitive index to assess response to therapeutic interventions in HF ⁽⁴⁾.

Pathologic left ventricular remodeling is the final common pathway to heart failure, whether the initial stimulus is chronic pressure or chronic volume overload, genetically determined cardiomyopathy or myocardial infarction. Cardiac remodeling is generally accepted as a determinant of the clinical course of HF ⁽⁵⁾. As cardiac remodeling of the left