ECHOCARDIOGRAPHY IN PATIENTS WITH CARDIOMEGALY IDENTIFIED ON CHEST X-RAY AT AN ACADEMIC HOSPITAL IN ZAMBIA

BY

NCHIMUNYA GWABA

STUDENT No: 213105810

A dissertation submitted in fulfilment of the requirements for the degree of Master of Science in Radiography: Department of Medical Imaging and Therapeutic Sciences. Faculty of Health and Wellness Sciences at Cape Peninsula University of Technology

Principal Supervisor: Ms Ferial Isaacs

Co-supervisor: Ms. Maria Hartnick

Collaborator: Dr. Bright Nsokolo

Bellville Campus

November 2018

Declaration

I, Nchimunya Gwaba, declare that the content of this dissertation represent my own unaided work, and that the dissertation has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the University.

NCHIMUNYA GWABA - 213105810

SIGNED

4 – 12 – 2018

DATE

Dedication

I dedicate this research to my wife, children, mother and brothers. Your encouragement and love have always been amazing to me. Thank you all.

“What is written without effort is in general read without pleasure.”

Samuel Johnson (1709-1784)

Acknowledgement

I acknowledge the following people for their support and encouragement towards the successful completion of this research.

1. My Principal Supervisor, Ms F Isaacs guided me throughout this study.
2. The Co-supervisor Mrs M Hartnick was very instrumental in guiding me especially on issues related to ECHO examinations.
3. The Head of the Medical Imaging & Therapeutic Sciences Department, Mr A Speelman, for his assistance.
4. The Collaborator, Dr B Nsokolo is a specialist in internal medicine and he was instrumental in making sure that the data I collected was factual.
5. The Director of Research for Postgraduate Studies at Apex Medical University, Dr T Sukwa, for proof reading and corrections of my thesis. Dr. Sukwa is also a former country director for the World Health Organization.
6. The Statisticians, Dr C Uys (CPUT) and Mr M Sinkala helped in analysing the data collected. Without their assistance, this project would not have been completed.
7. The Management and staff at Levy Mwanawasa Hospital, for permitting me to research at their facility and for their help during the course of the study.
8. My utmost gratitude and appreciation also to the patients whose clinical information was used in carrying out this research.

Abstract

Introduction: Cardiomegaly is a sign that there is an underlying cardiovascular disease. It is a medical indication in which the heart is enlarged. This indication is strongly associated with high blood pressure or coronary heart disease. When enlarged, the heart may pump blood ineffectively, and this can lead to congestive heart failure. Common underlying causes of cardiomegaly are heart failure, heart muscle disease (cardiomyopathy), coronary heart disease, high blood pressure (hypertension), congenital heart disease, heart valve disease, thyroid disease, and obesity. Cardiovascular diseases are very often accompanied by an enlarged heart and these diseases are the world's leading cause of death. Early detection of cardiovascular diseases in cardiomegaly patients is particularly important for the prevention of fatalities as cardiovascular diseases are the number one cause of diseases worldwide. Although the chest X-ray (CXR) is the number one imaging modality for cardiomegaly, echocardiography (ECHO), a dynamic ultrasound imaging modality of the heart can also be used to assess the functioning of the heart. In Zambia, no documented study has been done to establish the association between cardiomegaly identified on a chest x-ray and the results of the echocardiography reports of the same patients. The aim of this research study, therefore, was to establish whether there is an association between cardiomegaly identified on the CXR and the ECHO reports of the same patients.

Methodology: This retrospective cross-sectional study involved the retrieving of data from 124 patients who had cardiomegaly identified on the CXR and had undergone an ECHO examination. The study was performed at Levy Mwanawasa General Hospital (LMGH) in Lusaka, Zambia.

Findings: Cardiomegaly was detected in 124 patients *(n = 124*) on the CXR using the cardio-thoracic-ratio. Cardiomegaly was more prevalent in females (67.7% of participants were female) compared to males (32.3% of participants were male). All age groups were affected, however the prevalence increased with age; 60% of the patients were aged 60-80 years. More than 50% of the patients had severe cardiomegaly. There was no significant difference between males and females with severe cardiomegaly.

The ECHO findings showed left ventricular diastolic dysfunction as the most common condition (presented in 71% of the patients) followed by left atrium dilation (presented in

29.1% of the patients) and left ventricular systolic dysfunction (presented in 29% of the patients). Doppler ultrasound was used to detect abnormal blood flow patterns within the heart. It revealed a significant correlation between severe cardiomegaly and severely increased blood flow patterns (*p=0.004*); and between cardiomegaly (minimal, moderate, and severe) and increased blood flow patterns (p=0.002, p=0.000 and p=0.04 respectively). Other abnormal ECHO findings included: ejection fraction (presented in 36.3% of the patients), fractional shortening (presented in 31.5% of the patients) left atrial dilation (presented in 28.2% of the patients), tricuspid valve regurgitation (presented in 25.8% of the patients), right atrium dilation (presented in 24.2% of the patients), posterior wall thickness (presented in 23.4% of the patients), inter-ventricular septal thickness (presented in 22.5% of the patients), pericardial effusion (presented in 21% of the patients), left ventricular dilation (presented in 20.2% of the patients), right ventricular outflow tract (presented in 16.9% of the patients), mitral valve regurgitation (presented in 15.5% of the patients), aortic root dilation (presented in 8.8% of the patients) and pleural effusion (presented in 8.1% of the patients).

There was a strong positive association between severely increased blood pressure and cardiomyopathy *(p=0.023*), inter-ventricular hypertrophy (*p=0.017*), left atrial dilation (p=0.007) left ventricular diastolic dysfunction (p=0.045), left ventricular dilation (p=0.*003*), left ventricular hypertrophy (p=0.*028*), left ventricular systolic dysfunction (p=0. *048*) and pericardial effusion (p=0.*001*).

Conclusion: Cardiomegaly detected on the plain CXR of patients was found to be a helpful marker for cardiac diseases, as well as an index of its severity. While 7.2% and 4.8% of patients with minimal and moderate cardiomegaly had normal ECHO findings respectively, all patients with severe cardiomegaly were identified with cardiovascular diseases. Hence, the ECHO made an important contribution to the diagnosis of specific cardiac anomalies in patients identified with severe cardiomegaly. ECHO may be considered a useful screening tool for patients identified with cardiomegaly on the CXR in adults.

Contents

List of Abbreviations

BP- Blood Pressure

CPUT-Cape Peninsula University of Technology

CT – Computed Tomography

CHF-Congestive Heart Failure

CTR- Cardiac Thoracic Ratio

CXR- Chest X-Ray

DCM- Dilated Cardiomyopathy

ECHO – Echocardiography / Echocardiogram

EF - Ejection Fraction

IHD - Ischemic Heart Disease

LMGH - Levy Mwanawasa General Hospital

MR - Mitral Regurgitation

LVH - Left Ventricular Hypertrophy

LVEF - Left Ventricular Ejection Fraction

MRI – Magnetic Resonance Imaging

PA - Posterior Anterior

PW - Posterior Wall

WHO - World Health Organization

CHAPTER ONE
INTRODUCTION AND BACKGROUND

1.1. Overview

Cardiomegaly is an indication that there is an underlying cardiovascular disease. Tavora et al. (2012) explain that among adults with a main age of about 50 years, cardiomegaly is a frequent finding in cardiovascular diseases that may cause sudden cardiac death. Mckee and Ferrier (2017) indicate that a cardiothoracic ratio (CTR) greater than 50% on a posterior-anterior (PA) chest radiograph (CXR) is representative of cardiomegaly. However, authors like Brakohiapa et al. (2017) indicate that a cardiothoracic ratio of 55% may not have any underlying cardiovascular disease and may thus be considered normal for blacks and Asians.

The World Health Organization (WHO, 2016) estimates that more than 17 million people (representing 31% of all annual global deaths) die annually from cardiovascular diseases, globally. In America, a study by Aksut (2015) estimated that about 5 million Americans have symptomatic heart failure. Cardiovascular diseases are among the top ten leading causes of death in Zambia in 2016. Stroke is the fifth leading cause of death in Zambia while ischemic heart disease is the eighth. These two diseases account for 4.3% and 2.6% of the total deaths recorded respectively, in Zambia (World Health Ranking, 2016). It should be noted that the total prevalence of cardiovascular diseases in Zambia is 8% (WHO, 2014).

This study was designed to investigate the association between cardiomegaly diagnosed on the chest X-ray (CXR) and the echocardiography (ECHO) findings of the same patients. The recognition of cardiomegaly was based on the cardiothoracic ratio calculations on the CXR, and cardiac pathologies were investigated using ECHO. The investigated individuals were aged between 18 to 80 years (mean age was 56.78).

1.2 Background

An enlarged heart may be accompanied by cardiovascular diseases. More than 17 million (31%) people die worldwide, annually from cardiovascular diseases (WHO, 2016). Many of these people have been exposed to unhealthy behaviours, including tobacco use,

eating foods containing too much salt and inadequate physical activity. Most of these people could be saved by better access to medical care for high blood pressure (responsible for the bulk of heart disease-related deaths annually), high blood cholesterol and other conditions that raise the risk for cardiovascular diseases.

At Levy Mwanawasa General Hospital (LMGH), records show that cardiovascular diseases were the third leading cause of death (8.6%) in 2015. A total of 3044 patients (8.5% of total patients seen) were seen with various cardiovascular diseases at LMGH in 2015. Out of these 1760 patients had hypertension, 470 had heart failure, 320 had ill-defined heart conditions, 284 had cerebral vascular accidents, 146 had cardiomyopathy, 55 had angina pectoris, 13 had chronic ischemic heart disease, 3 had non-rheumatic mitral valve disease, 3 had tachycardia and 1 had cardiac arrhythmia (LMGH, 2016). Most of these cardiovascular diseases were accompanied with cardiomegaly. As shown by records from LMGH (2016), it can be estimated that about 16.7% of all CXR examinations had cardiomegaly.

The association between an enlarged heart diagnosed on the CXR and the ECHO findings of the same patient, have not yet been documented at this hospital. With the projected rise in the incidence of cardiovascular diseases worldwide, it is expected that the incidence of cardiomegaly will continue to rise in Zambia, in particular at LMGH.

Experts have explained that there is a strong clinical association between cardiomegaly and cardiovascular diseases. Monfared et al (2015), explain that cardiomegaly is caused by different diseases, such as valvular heart diseases, Ischemic heart disease (IHD), and cardiomyopathy as well as pericardial diseases.

Cardiomegaly is thus a serious indication of cardiovascular diseases and early diagnosis of the pathological conditions found in cardiomegaly can be of great benefit to both the patients as the underlying disease can be treated. It was thus important to investigate the associate pathological conditions found in patients with cardiomegaly at LMGH in Lusaka, Zambia, as this can help to put measures in place that can reduce incidences for these diseases. The findings may also help identify the gaps in equipment and qualified manpower needed to diagnose and treat these conditions.

This research study was conducted at LMGH in Lusaka, Zambia. The study is the first of its kind at the research site in particular and Zambia in general. The study was quantitative, retrospective, and descriptive. Files for patients with an enlarged heart on a

CXR who had undergone an ECHO examination, were used to determine the association between patients diagnosed with an enlarged heart on CXR and ECHO findings of the same patients.

1.3 Problem statement

Cardiomegaly is one of the most common findings on CXR and ECHO examinations in the world (Monfared et al, 2015; Tomaszewki, 2012; Elliot et al, 2000; Tavora et al, 2012). It was estimated that 16.7% of the CXR examinations done at the study site showed cardiomegaly and some patients with an enlarged heart are referred for the ECHO examination, which provides a more detailed assessment of the structure and function of the heart. It is however unclear to what the association is between cardiomegaly and ECHO findings of the same patient at this study site. Thus, this retrospective study aimed to establish whether there is an association between cardiomegaly identified on the CXR with pathological findings of echocardiography.

1.4 Justification of the study

The justification for this study was that identifying the association between cardiomegaly diagnosed on a CXR and the ECHO results of the same patients, who presented at the study site, may increase awareness of the association and thus the common cardiovascular diseases found in such patients among clinicians, radiographers as well as patients. These findings may help re-asses the need for further management of patients identified with cardiomegaly on a CXR and may also lead to the early referral for ECHO examinations for such patients in communities serviced by the research site.The expected findings may also help determine the prevalence of actual cardiovascular diseases at LMGH and may help stimulate interest in further research to identify gaps in equipment and or qualified man power needed to diagnose and treat prognostic markers of cardiomegaly.

1.5 Benefits of the study

This study may benefit clinicians, radiographers and patients because the study is seeking to confirm that cardiomegaly identified on a CXR can be an indicator of underlying cardiovascular diseases. This may lead to awareness of the possible need for an early CXR and ECHO in the diagnosis and treatment of cardiovascular diseases.

This may help channel resources to prevention measures like awareness programs on radio, training of more manpower, and also in the purchase of medicines and equipment needed to manage these conditions. Increased awareness of the frequent pathological findings in cardiomegaly patients may also have important implications when prioritizing funding for future research and treatment of patients with cardiomegaly/cardiovascular diseases.

1.6 Research question

Is there an association between cardiomegaly identified on the CXR and ECHO results of the same patient?

1.7 Aim of the study

This study aimed to establish whether there is an association between the CXR reports of patients diagnosed with cardiomegaly and the ECHO reports of the same patients.

1.8 Objectives of the study

The objectives of the study were:

1. to establish whether there was an association between cardiomegaly (cardiac-thoracic ratio) diagnosed on a CXR and ECHO findings,
2. to establish whether there was a significant difference and correlation in the CXR and ECHO findings, between males and females, and between different age groups respectively, and
3. to establish the prevalence of pathological conditions found on the ECHO in patients diagnosed with an enlarged heart on the CXR

1.9 Rationale

The prevalence of cardiovascular diseases in Zambia is 8% (WHO, 2014) and 8.5% at the research site (LMGH, 2016). Monfared et al. (2015), Tomaszewki (2012), Elliot et al. (2000) and Tavora et al. (2012) have all shown that cardiomegaly is the most prominent diagnosis on a CXR and ECHO globally. In Zambia, the frequent pathological findings in cardiomegaly patients are not well documented. Therefore, this study sort to investigate, the association between cardiomegaly diagnosed on the CXR and the ECHO reports of the same patient. The study was conducted at an academic hospital in Lusaka, Zambia.

The results, including recommendations, are reported in the thesis format to the educational institution Cape Peninsula University of Technology (CPUT), and the study site. Thus, the consulting cardiologist, physicians, clinical educators and the broader research community have access to the results of this research, from the above-mentioned institutions (e.g. via their web sites).

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

The literature reviewed focused on establishing the various chest x-rays (CXR) and echocardiography (ECHO) patterns in patients with cardiomegaly. The abstracts of all articles were reviewed, and the full manuscript of the relevant articles retrieved. The databases that were consulted for this literature review included Google scholar, Science direct, Promed, Wiley online, Elsevier, Sciverse, Medline, Springer link, Medscape, Hospital management information systems for Levy Mwanawasa General Hospital, United Nations website, Ministry of Health (Zambia) website and some medical textbooks.

What is important in the case of cardiomegaly is to be able to demonstrate the presence of underlying diseases that could lead to the occurrence of cardiomegaly. Such information could be obtained from a CXR and ECHO. The CXR provided information on lung pathology (that may be the cause of the cardiomegaly) and the size of the heart, while the ECHO provided information on the structural and functional changes in parts of the heart. Arguments are presented, from the literature, on the need for Levy Mwanawasa General Hospital the CXR and ECHO examination in the diagnosis of cardiovascular diseases.

2.2. Cardiomegaly

Cardiomegaly means that the heart is enlarged. It is usually a sign of another cardiovascular condition. There are two main types of cardiomegaly and these are:

I. **Dilated** - Dilated cardiomyopathy is characterized by a severe, irreversible form of heart diseases with left ventricular systolic dysfunction and dilation. In dilated cardiomegaly, the heart becomes enlarged due to dilation of the myocardium (De Luca, et.al 2018).

   Dilated cardiomyopathy ranks among the most common causes of heart failure in the world. It has highly variable clinical presentation and prognosis and is the second leading cause of left ventricular dysfunction. Clinical causes are many and are highly heterogeneous, ranging from patients who are asymptomatic to those

suffering from sudden cardiac death due to arrhythmias or intractable heart failure. A cardiovascular mortality of up to 40% has been reported in developed countries from previous studies, mainly due to sudden cardiac death or advanced heart failure. Thus, dilated cardiomyopathy prognosis depends on multiple risk factors and is variable. While symptoms and signs of dilated cardiomyopathy may be common, some are incidental, for example, by identifying cardiomegaly on a CXR (Schild et al., 2019).

It can be said that dilated cardiomyopathy is the final common response of myocardium to environmental and diverse genetic insults. Alternative causes of left ventricular dilation and dysfunction can be excluded by a rigorous work-up, this can also help identify etiologies that may guide family screening and respond to specific treatments. Most of the dilated cardiomyopathy cases have an underlying inflammatory or genetic basis. Although other aspects of cardiac remodelling inform prognosis and carry therapeutic implications, measurement of ejection fraction and left ventricular size remains central to diagnosis, stratification, and treatment. Examining for myocardial fibrosis predicts both risk of likelihood of left ventricular functional recovery and sudden cardiac death. In depth assessment of the mitral valve is likely to assume increasing importance with the emergence of percutaneous interventions for functional mitral regurgitation. Identifying of pre-clinical dilated cardiomyopathy could greatly reduce morbidity and mortality by allowing early instigation of cardio protective therapy (Japp, 2016).

II. **Hypertrophic** – In hypertrophic cardiomyopathies, the walls of the heart are abnormally thickened and the chambers are small. The heart is thus not able to supply adequate blood to the whole body (Sanders & Terracciano, 2016).

Hypertrophic cardiomyopathy (HCM) is a primary and mostly familiar cardiac disorder with a diverse clinical course, heterogeneous expression, and unique pathophysiology. Clinically, hypertrophic cardiomyopathy has a hypertrophied non-dilated left ventricle without any other cardiac or systemic disease that could produce the extent of hypertrophy observed. In most patients dying from HCM, cardiomegaly has been observed to be in the range of twice the normal heart weight. The common histological features in HCM are the presence of myofiber disarray, marked myocyte hypertrophy, intramural coronary abnormalities, left

ventricular outflow tract plaque, interstitial fibrosis and intramural coronary abnormalities. The pathophysiology of HCM is complex and consists of multiple abnormalities, including diastolic dysfunction, ventricular outflow tract obstruction, myocardial ischemia, mitral regurgitation and arrhythmia (Sakamoto et al., 2018). Most patients with HCM have a relatively benign course. But HCM is an important cause of sudden cardiac death, particularly in young adults and adolescents. None sustained syncope, ventricular tachycardia; severe cardiac hypertrophy and sudden cardiac death are sudden major risk factors for sudden cardiac death (Marian & Braunwald, 2017).

2.3. Pathophysiology of Cardiomegaly

There are a lot of changes to how the body and its systems work when cardiomegaly occurs. This is because some changes in the heart lead it to pump much harder than usual, or these changes cause damage to the heart muscles. Some of the most common causes of an enlarged heart and the changes they cause to the body and its systems are:

- heart failure due to heart attack
- cardiomyopathy (heart muscle disease)
- hypertension (high blood pressure)
- pericardial effusion
- thyroid disease
- congenital heart disease

- **Heart failure-** Heart failure is a common clinical syndrome usually identified with fatigue, dyspnoea, and signs of overload, which may include pulmonary rales and peripheral oedema. Heart failure has high mortality and morbidity rates, especially in persons with advanced age. The vast majority of conditions, such as hypertension, coronary artery disease, diabetes mellitus and valvular heart disease, can lead to or cause chronic heart failure. Between 40 to 50% of patients with heart failure have diastolic heart failure with preserved left ventricular function, and their overall mortality is similar to that of systolic heart failure. Their initial evaluation includes an assessment of history and physical examination, the CXR and ECHO to identify precipitating factors or causes. A

third heart sound, displaced cardiac apex, and CXR findings of interstitial oedema or venous congestion are useful in identifying heart failure. ECHO is the diagnostic standard to confirm diastolic or systolic heart failure through examination of the left ventricular ejection fraction. Evaluation for ischemic heart disease is important in patients with heart failure, especially if angina is present, given that coronary artery disease is the most common cause of heart failure. The CXR should be the initial test of choice to evaluate for heart failure because it can identify pulmonary causes of dyspnoea. Findings, such as cardiomegaly or pleural effusion, may slightly increase the possibility of heart failure. Another diagnostic tool that can be used to identify other causes in patients with suspected heart failure is electrocardiography (ECG). Changes such as left ventricular hypertrophy, bundle branch block, acute or previous myocardial infarction or arterial fibrillation can be identified and may warrant further investigation by stress testing, ECHO, or cardiology consultation (King et al., 2012).

- **Cardiomyopathy -** Cardiomyopathy literally means disease of the heart. Functionally, the heart has decreased ability to pump blood to the body. The most common types are hypertrophic and dilated cardiomyopathies. In hypertrophic cardiomyopathy, the walls of the heart are abnormally thickened and the chambers are small. Thus, the heart is not able to supply adequate blood to the entire body (Sanders & Terracciano, 2016). Pathologically, hypertrophic cardiomyopathy is characterized by ventricular hypertrophy, which may be localized or diffuse to the septum, ventricular free wall, or apex. Patients with septal hypertrophy are classified further into those without or those with evidence of dynamic obstruction to left ventricular outflow. The most common form of hypertrophic cardiomyopathy is associated with septal hypertrophy. The left ventricular cavity usually appears small and the ventricular apex may be completely obliterated in systole. The mitral valve may appear normal, but mostly, there are subtle anomalies of the mitral apparatus. Mitral regurgitation most often relates to the anatomy apparatus and to a degree of outflow tract obstruction (Boxt & Abbara, 2016).

Dilated cardiomyopathy is a cardiac disorder defined by the presence of a poorly functioning and dilated left ventricle. In this condition, the heart becomes weakened and enlarged. It is characterized by impaired systolic function of one or both ventricles with normal left ventricular wall thickness. (De Luca et al, 2018). Typically, all chambers of the heart enlarged thus both the right and left ventricles appear diffusely hypokinetic. In some patients, regional dysfunction may be seen because of preservation of systolic function at the base of the left ventricle or because of the presence of left bundle branch block, which causes paradoxical septal motion (Boxtn & Abbara, 2016). Transthoracic ECHO should be performed on all patients with suspected cardiomyopathy to confirm its presence, assess etiology, and determine its extent.

- **Pericardial effusion and pericardial tamponade -** Pericardial effusion is a common finding on CXR, either as an incidental finding or as a manifestation of a systemic or cardiac disease. The range of pericardial effusion can be from mild asymptomatic effusions to cardiac tamponade. Moreover, pericardial effusion can accumulate slowly or suddenly. When a pericardial effusion is identified, the first step is to evaluate its size and haemodynamic importance and its possible association with concomitant diseases. Pericardial effusion may be identified based on its distribution (circumferential vs loculated), haemodynamic impact (none, cardiac tamponade, effusive-constrictive), onset (acute, sub-acute and chronic when dating > three months), composition (exudates, transudate, blood, rarely air, or gas from bacterial infections), based on a simple semi quantitative ECHO assessment has been demonstrated useful to estimate the risk of specific aetiology and complications during follow up (Imazio & Adler, 2013).

  Pericardial effusion is a common cause of death worldwide. It can be due to diseases of the pleural or extra pleural, mostly cardiopulmonary, though anatomical variations are common disorders. Most pericardial effusions in developed countries (more than 90%) are due to congestive heart failure, pneumonia, malignancy and pulmonary embolism. Tuberculosis is another common cause in endemic countries (Thomas & Lee, 2013). ECHO is a sensitive diagnostic method for the diagnosis and localization of pericardial effusion. The size of the pericardial effusion is mostly described semi-quantitatively as being

small, moderate or large. When large, the heart swings freely in the pericardial sac. In some circumstances, the image may suggest the presence of a specific pericardial abnormality such as fibrin, tumour or organized hematoma (Boxt & Abbara, 2016).

- **Congenital heart disease -** Congenital heart diseases are cardiac anomalies that one is born with; these may include anomalies that may enlarge the heart.

  Pulmonary and cardiac pathophysiology are closely related, which complicates the management of patients with congenital heart diseases. Pulmonary complications of congenital heart diseases can be structural due to compression causing airway atelectasis of the lungs or airway malacia. Surgical repair of congenital heart disease can also lead in structural trauma to the respiratory system, for example, sub glottic stenosis, chylothorax, or diaphragmatic paralysis. Disruption of the starling forces in the pulmonary vascular system in certain types of congenital heart disease lead to pulmonary oedema and alveolar-capillary membrane damage. This in turn leads to poor compliance of the lungs with a restrictive lung function pattern that can deteriorate to cause hypoxemia. The circulation of post single ventricle palliative surgery poses a unique spectrum of pulmonary pathophysiology with restrictive lung function and a low pulmonary blood flow state that predisposes to plastic bronchitis and thromboembolic complications (Healy et al. 2012).

- **Thyroid disease-**Cardiac function has an intimate relationship with thyroid hormones. It has a profound effect on the cardiovascular system and the heart. Some of the most significant symptoms and clinical signs of thyroid disease are cardiac manifestations. In both hyperthyroidism and hypothyroidism, the characteristic physiological effects of thyroid hormone can be understood from the actions at the molecular and cellular level. Common clinical features of hyperthyroidism include tachycardia, goitre, and cardiomegaly (Klein &Danzi, 2016).

  Specifically, thyroid hormones like triiodothyronine have significant effects on the cardiovascular system and the heart. Hyperthyrodism, hypothyroidism, subclinical thyroid disease and low triiodothyronine syndrome each cause cardiovascular and cardiac abnormalities through both genomic and non-genomic effects on cardiac

myocytes and vascular smooth muscle cells. In compromised health, such as it occurs in heart diseases, alteration in thyroid hormone metabolism may further impair cardiovascular and cardiac functions. Diagnosis and treatment of cardiac diseases may benefit from including analysis of thyroid hormone status, including serum total triiodothyronine levels (Danzi& Klein, 2014). It should be noted that thyroid hormones modulate all the components of the cardiovascular system necessary for normal cardiovascular function and development, including heart size.

- **Pulmonary hypertension**

  Pulmonary hypertension (PH) is identified by an average pulmonary artery pressure ≥25mm Hg at rest, measured during right heart catheterization. Pulmonary arterial hypertension (PAH) describes a subpopulation of patients with PH characterized hemodynamically by the presence of pre-capillary PH including an end-expiratory pulmonary artery wedge pressure (PAWP) ≤15mm Hg and a pulmonary vascular resistance >3 wood units (Hoeper et al., 2013).

  Despite the notion that left heart diseases are believed to represent the most common type of pulmonary hypertension, Tudar et al. (2013) explain that while PH primarily affects the arteries, venous diseases are increasingly recognized as an important entity. Moreover, the prognosis is that PH is identified largely by the status of the right ventricle, rather than the levels of pulmonary artery pressures. It is increasingly clear that although vasospasm plays a role, PH is an obstructive lung pan vasculopathy. Disordered metabolism and mitochondrial structure, inflammation and deregulation of growth factors lead to a proliferative, apoptosis-resistant state. These abnormalities may be genetically mediated as a result of mutation in bone morphogenetic protein receptor-2, acquired or active in-like kinase-1, or epigenetically inherited (as a result of epigenetic silencing of genes such as superoxide dismutase-2). The pulmonary circulation is a central determinant of right ventricular after load and an increase in right ventricular ejection impedance can rapidly result in right ventricular failure, tricuspid regurgitation and central venous pressure rise.

  Conditions such as cor pulmonale, associated with right ventricular hypertrophy and dilation secondary to pulmonary hypertension caused by respiratory disorders

are common in PH. ECHO is an important screening tool in the diagnostic algorithm of such conditions. ECHO also provides estimates of arterial pressure, either during exercise or at rest and is useful in ruling out secondary causes of PH. Furthermore, ECHO is important in assessing treatment options and prognosis, monitoring the efficiency of specific therapeutic and detecting preclinical stages of diseases.

- **Hypertension**

  Hypertension is a one of the major risk factors for cardiovascular mortality and morbidity, including heart failure with both preserved and reduced ejection fraction. Hypertensive heart disease (HHD) denotes the complex and diverse perturbations of cardiac structures and functions occurring secondary to hypertension. Left ventricular hypertrophy (LVH) is one of the recognized findings. Beyond LVH, left ventricular geometry provides additional data regarding the cardiac response to hypertension. Studies from larger cohorts of hypertensive patients reveal a wide variability in the prevalence of LVH and left ventricular geometric patterns, with the prevalence of concentric LVH similar to that of eccentric LVH. Hypertension is also related with concomitant impairments in LV diastolic and systolic function as well as an increase in left-sided filling pressures (Santos & Shah, 2014).

  In addition, Guazzi et al. (2011) explain that multifaceted response to phosphodiesterase-5 inhibition in heart failure with preserved ejection fraction includes improvement in pulmonary vasomotility and pressure, right ventricular function and dimension, left ventricular relaxation and distensibility (structural changes and ventricular interdependence) and lung interstitial water metabolism. These increase our knowledge of heart failure with preserved ejection fraction.

2.4. Prevalence of cardiomegaly

Cardiovascular diseases, including heart attacks and strokes, are the world's leading cause of death. More than 17 million people die annually from cardiovascular diseases (World Health Organization, 2016). According to Aksut (2015), approximates 5 million Americans have symptomatic heart failure, but it has been estimated that 50 million

Americans fulfils the American Heart Association–American College of Cardiology's definitions of heart failure.

In Zambia, cardiovascular diseases are among the top ten causes of death. In this vain, stroke is the fifth leading cause of death (4.3%) while ischemic heart disease is the eighth (2.6%) (World Atlas.com, 2016). On the other hand, in Lusaka, Zambia, records from the study site (2016) indicate that cardiovascular diseases are the third leading cause of death (8.6% of the total deaths recorded), surpassed only by tuberculosis and Immune suppression diseases. It should be noted that most cardiovascular diseases are very often accompanied by an enlarged heart; therefore, cardiovascular diseases are quite common in patients with cardiomegaly.

Studies by different researchers have confirmed that cardiomegaly is prominent around the world and the CXR and ECHO have been used to provide evidence of this fact. For example, in a 170 patients-study conducted by Ryszard (2012) at the Madonna University Teaching Hospital in Nigeria, cardiomegaly was revealed by chest radiographs. In this study, patients also underwent echocardiography. Arterial hypertension was found to be most frequently associated with heart enlargement (39.4%), followed by dilated cardiomyopathy (21.76%), endomyocardial fibrosis (14.1%), valvular defects (9.4%) and cardiac enlargement in the course of sickle-cell anaemia (6.47%).

Tomaszewski (2012) estimates that cardiomegaly is found in 5-7% of CXR film evaluations in tropical Africa. Furthermore, according to a study conducted from 57 hospitals in seven countries around the world, Elliot et al. (2000) found that the most common chest radiographic interpretations were cardiac enlargement (27%). In addition, Tavora et al. (2012) carried out a research in which it was discovered that among adults with a mean age of about 50 years, cardiomegaly is a frequent cause of sudden cardiac death. The prevalence of cardiomegaly was estimated to be 16.7%, as shown by records from the X-ray department register at LMGH (LMGH, 2015).

2.5. Common indications associated with cardiomegaly

According to Monfared et al. (2015), cardiomegaly is caused by different diseases, including valvular heart diseases, ischemic heart disease (IHD), and cardiomyopathy as

well as pericardial diseases. Tomaszewski (2012) agrees with this point and further explains that the most common causes of an enlarged heart are:

- left ventricular hypertrophy
- heart muscle disease (cardiomyopathy)
- endomyocardial fibrosis
- valvular defects
- sickle cell anaemia
- pericardial effusion

Cardiomegaly, especially in the middle-aged and elderly patients, is correlated with IHD and increased rate of morbidity and mortality. An enlarged heart size is, therefore, an independent predictor of death, and an increased cardiothoracic ratio (CTR) on a CXR, irrespective of its aetiology, is associated with poor prognosis in middle-aged patients. This issue is indicative of great importance and necessity of early diagnosis, especially in older patients (Lavie et al. 2009, Artham et al. 2009 and Screaton et al. 2010). Causes of cardiomegaly on a CXR can be due to left ventricular dilatation, right ventricular dilatation, left, right or bi arterial enlargement, underlying valvular heart disease-causing such chamber dilatation and or pericardial effusion (Tam, 2006).

Risk factors for cardiomegaly include hypertension, cardiac diseases, diabetes, hypercholesterolemia, cigarette smoking, illicit drug use, alcoholism and pulmonary diseases. Other lifestyle-based risk factors are obesity, lack of physical activity and poor diet (World Heart Federation, 2017).

2.6. Imaging modalities for cardiomegaly

In the modern clinical setting, the practitioner can request a variety of imaging procedures for the evaluation of cardiomegaly patients. Modern diagnostic imaging offers a vast spectrum of modalities and techniques, which enables us to study the function and morphology of the human heart in detail. However, it should be noted that even in the most advanced imaging department in the economically privileged parts of the world, all clinically relevant questions about the heart may be solved by using the two main cornerstones of diagnostic imaging, which are radiography (CXR) and echocardiography.

Diagnostic X-rays of the chest and echocardiogram examinations were the two diagnostic tools that were used during this research study.

2.6.1. Chest X-Ray

In radiology, a CXR is used to diagnose conditions affecting the chest, its contents, and nearby structures. Chest radiographs are the most common imaging in medicine. Like all methods in radiography, chest radiographs employ ionizing radiation in the form of x-rays to generate images of the chest. The CXR provides information about heart size. Misra et al. (2007) explain that heart size is one of the important and effective parameters in the CXR interpretation. Therefore, a good quality posterior-anterior (PA) chest radiograph is an important indicator of the cardiac size. Assessment of cardio-medial steno contour involves the right side (superior vena cava and right atrium), the anterior aspect (right ventricle, cardiac aspect and left ventricle) and left side (left ventricle, left arterial appendage, pulmonary trunk and the aortic arch).

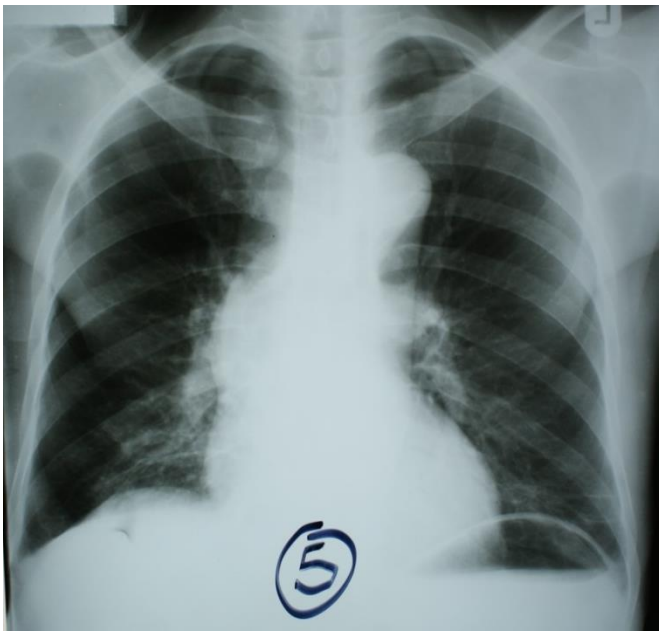

Figure 1: Chest x-ray image showing the heart shadow (*courtesy of LMGH*)

A Wang Dong medical (WDM) digital X-Ray machine was used at the study site to capture chest X-ray images.

Therefore, right-sided heart strain and resulting hypertrophy manifest as cardiomegaly on imaging. Right ventricle enlargement is observed as an obliteration of clear space on lateral CXR, whereas right atrium enlargement is seen as prominence of right heart

border on a posterior anterior projection; dilation of central pulmonary arteries; pruning (loss) of peripheral blood vessels. Pericardial effusions can also be seen on the CXR and is characterized by an enlarged cardiac silhouette; lateral views may outline the divides among the pericardial fluid, epicardial and pericardial fat. The CXR can also be helpful in supporting the diagnosis of left-sided heart disease and for evaluating lung parenchymal diseases such as interstitial lung disease and emphysema (Ascha et al., 2017).

Monfared et al. (2015) indicate that a well taken quality posterior-anterior (PA) chest radiograph is thus a reliable method for assessing cardiac size. However, the CXR is now being supplemented by more advanced approaches such as echocardiography, magnetic imaging resonance (MRI) and computed tomography (CT) scanners. But authors like Gollub et al. (2012) explain that in patients with cancer and undergoing routine ECHO, the CTR at routine CT scans was highly associated with that of a CXR.

While a CXR can help steer the further diagnostic path, it suffers limitations. Some of the major limitations are the nonspecific nature of the findings and lack of correlation of disease severity with the extent of radiographic abnormalities (Ascha et al., 2017).

Recent technological innovations in CT and MRI of the heart have vastly expanded the clinical utility of these modalities allowing them to complement and in some ways surpass the capabilities of more traditional methods. Cardiac MRI has an unrivalled ability to assess contractile function, characterize tissue, and detect minute areas of scar. In turn, cardiac MRI can reliably risk stratifying ischemic heart disease and has emerged as a non-invasive gold standard technique for imaging non-ischemic cardiomyopathies (Parsai et al, 2012). However, Morales et al. (2012) indicates that a CXR is still considered a reliable technique in predicting left ventricular dilatation by accurately measuring the transverse diameter of the heart shadow as compared to MRI.

Cardiac CT, by comparison, reveals the cardiac structure and, in particular, coronary anatomy with remarkable sub-millimetre detail. For the first time, coronary stenosis can be directly and reliably visualized non-invasively. Owing to its very high negative predictive value for the detection of significant coronary obstruction, cardiac CT can accurately exclude coronary disease as a cause of chest pain in low to intermediate-risk populations (Greenwood, 2012).

However, CXR is still more accessible, feasible and cost-effective, and thus remains the most common imaging examination of the heart. At the research site, the CXR and ECHO examinations are preferred in the diagnosis of cardiomegaly as these are readily available, accessible and cheap.

2.6.2. Heart size on a chest X-Ray

Heart size is an important and helpful evaluation parameter on a CXR (Monfared et al., 2015). Revannasidaiah (2013) defines cardiomegaly by a simple and time-tested method, using a posterior-anterior chest radiograph obtained in mid-inspiration, as a 'cardiothoracic ratio greater than 0.5'. The cardiothoracic ratio is in turn calculated by measuring the distance from the midline to the most lateral aspect of the left and right cardiac silhouette borders and dividing the sum by the maximum horizontal measurement of the thorax, from the left to right pleural surface at the level of the diaphragmatic apices.

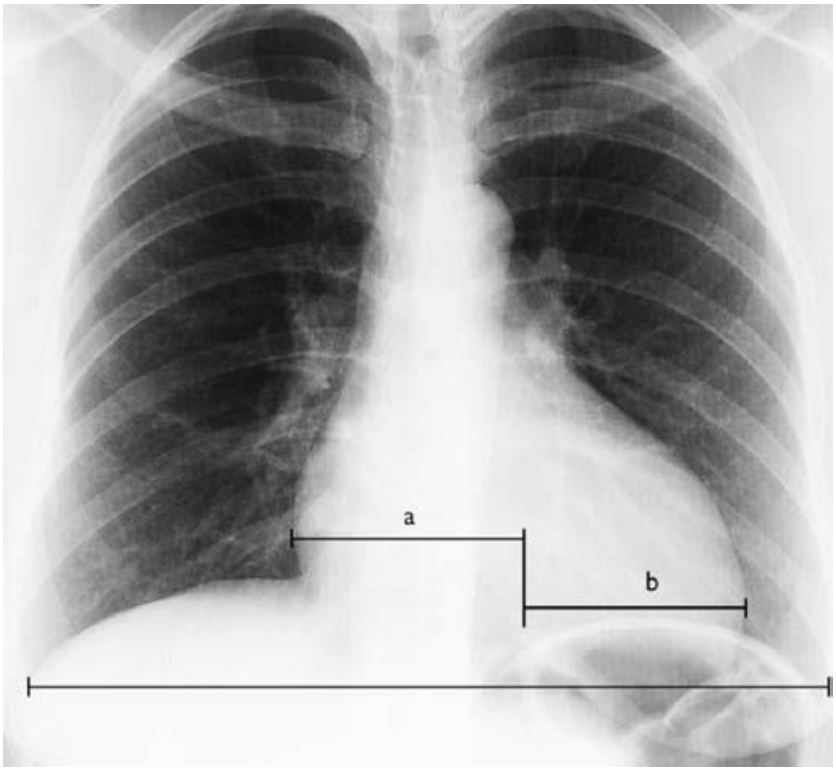

Figure 2: Image showing the CTR measurements (Patel, 2010)

Mensah et al (2015) agrees with the above-mentioned authors and goes on to explain that CTR is a simple method in the calculation of heart size and is a useful index of cardiac size evaluation. A value of 50% is considered to be the upper limit of normal. The above-

mentioned calculation (A+B/C) was used to measure the CTR at the research site (figure 2 above).

It can be said that cardiothoracic ratio and the transverse cardiac diameter on a plain CXR are the two parameters commonly used to identify cardiomegaly and diagnose heart disease. A CTR which is greater than 50% on a PA CXR film is abnormal and normally signifies cardiac or pericardial disease; while an enlargement of transverse cardiac diameter from 1.5 to 2cm on two consecutive CXRs, taken at short interval, suggests possible cardiac pathology (Brakohiapa, 2017). Furthermore, it should be noted that CTR is a simple method in the estimation of heart size. It is an important index of cardiac size evaluation, and a value of 50% is generally considered to indicate the upper limit of normal (Mensah et.al, 2015). The CTR is thus a clinical metric of heart size on a CXR and is a key indicator of cardiomegaly (Dong et al., 2018).

2.6.3. Echocardiography

ECHO is fundamental in the management of patients with cardiovascular pathology (Kaddoura, 2009). ECHO is now being used to confirm the heart size measured on the CXR in most hospitals. It provides information on heart anatomy and an estimate of haemodynamics and biventricular remodelling and function. Furthermore, ECHO is valuable in assessing prognosis and monitoring the efficacy of therapy (D'Alto, 2016).

ECHO can provide important information throughout the whole patient pathway, having been shown to change therapy in 60-80% of patients in the pre-hospital setting, improve diagnostic accuracy and efficiency in the emergency room, reveal the aetiology of unexplained hypotension in 48% of hospital intensive care patients and provide additional information to that obtained from the pulmonary artery catheter. ECHO is thus now included in the universal definition of acute myocardial infarction (AMI), and in international guidelines on how to manage cardiac arrest. In critical care setting, ECHO may be used to measure/monitor cardiac output and to determine abnormalities of cardiac physiology and coronary perfusion, as well as providing more standard anatomical data related to diagnosis (Lancellotti et al., 2014).

Tam (2006) describes the echocardiogram as a non-invasive ultrasound assessment of the heart and the big vessels. It differs from an ordinary ultrasound scan by providing information on:

I. function, both dynamic systolic and diastolic
II. hemodynamic
III. anatomy of the heart and related big vessels

In addition, ECHO is used in the evaluation of valvular dysfunction and abnormal left ventricular function and to estimate left ventricular ejection fraction. Other uses include the assessment of the structural cause of arterial fibrillation, its risk of thrombus embolism and the diagnosis of congenital heart disease and cardiomyopathy (Tsang, 2000). It can thus be said that ECHO allows the visualization of cardiac structures, cardiac walls and the velocity of blood flow at certain points in the heart. Figure 2 below shows the ECHO appearance of the heart as was captured at the research site.

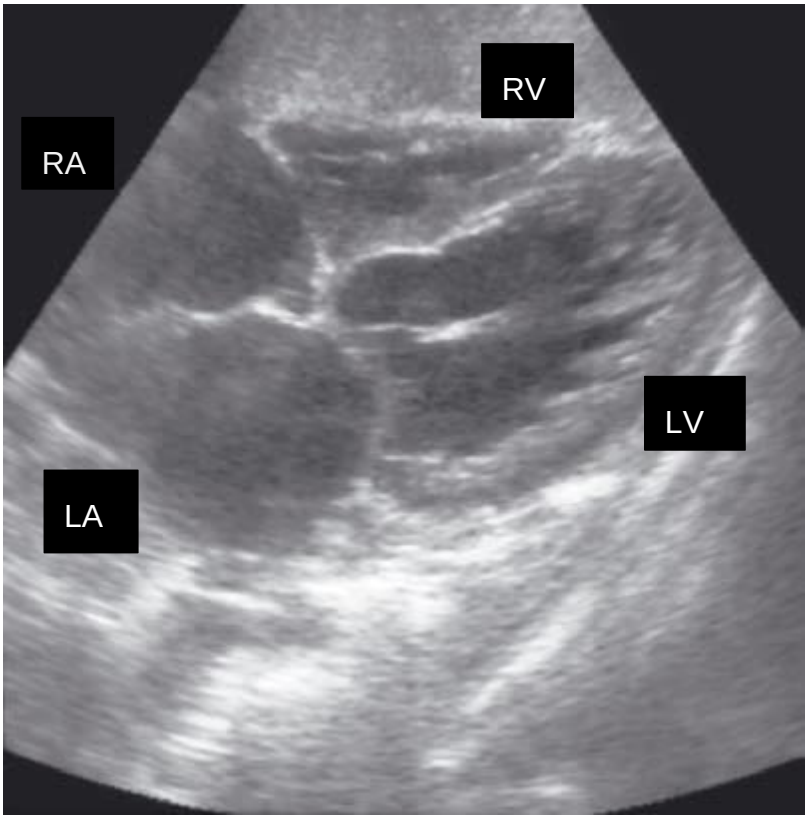

Fig 3: ECHO of the heart: subcostal view demonstrating four chambers of the heart: left and right ventricle, left and right atrium (Patel, 2010)

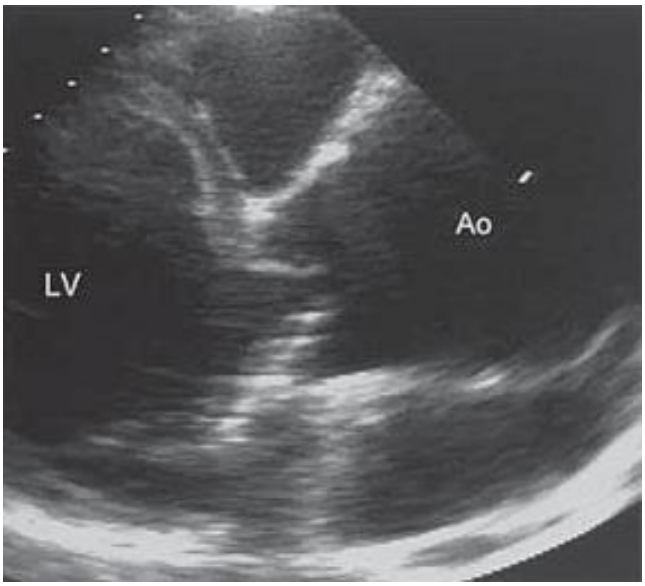

Fig 4: 2-D ECHO of the heart: parasternal long-axis view showing LV dilatation (Kadura, 2009)

2.6.4 Principles of operation for equipment used

A Sonoscape model ssi-3000 digital ultrasound machine was used in this study. The machine has the following features: (https://www.scribd.com/document/316605317/Sonoscape-Ssi-3000-Basic-Manual)

a. Image production

Two basic principles govern the production of the ultrasound image:

(i) The piezoelectric micro machined ultrasound transducers diaphragm like thin film flexural transducers typically formed on silicon substrates, are a potential solution for integrated transducer arrays (Qiu, 2015). The piezoelectric effect explains how ultrasound is generated from ceramic crystals (zirconate and titanate) in the transducer. An electric current is applied to the crystals, causing them to change shape and vibrate, resulting in the generation of a sound wave. Thus this vibration produces the ultrasound beam. The frequency of the ultrasound waves produced is predetermined by the crystals in the transducer (Kealy & Mcallister, 2010; Sanders & Terracciano, 2016).

(ii) The pulse-echo principle explains how the image is generated. Ultrasound waves are produced in pulses, not continuously, because the same crystals are used to generate and receive sound waves, and they cannot do both at the same time. The ultrasound beam penetrates tissue and is either reflected to the transducer, transmitted through the tissue (patient), absorbed by the tissue or scattered. The reflected sound waves or echoes form the ultrasound image. The reflected echoes cause the crystals in the transducer to change shape again and produce an electrical signal that is then converted into an image displayed on the monitor. (Nyland et al., 2002; Sanders & Terracciano, 2016).

b. B-Mode real-time imaging is a grey-scale presentation of the 2-dimension view of tissue in real-time. The main advantages are:

(i) it is dynamic e.g., movement of cardiac valves can be seen, and

(ii) the grey scale allows for good soft tissue differentiation.

At the study site, 2-D ECHO was used to give snapshots in real time of a cross section of the heart. These sections were produced in rapid succession and displayed on a monitor, showing 'real time imaging' of the heart chambers, valves and blood vessels.

c. M-mode echo

Motion or M-mode ECHO produces a graph of depth and strength of reflection with time; changes in motion (e.g. valve opening and closing or ventricular wall movement) can be displayed. The ultrasound signal should be perpendicular to the structure being examined. Measurements of the size and thickness of the cardiac chambers can be made either manually on paper print outs or on the screen monitor using computer software (Kaddoura, 2009). At the study site, M-mode echo was used to produce a graph of strength and depth of reflection with time of moving structures. Changes in motion, including valve opening and closing or ventricular wall movement, were displayed and analysed.

d. Doppler imaging

Doppler ultrasound provides information regarding the identification of blood vessels; direction of blood flow as well as the measurement of blood-flow velocity. The Doppler Effect is calculated using the frequency change between the transmitted and reflected sound waves in moving fluids (Sanders & Terracciano, 2016).

e. Continuous- wave Doppler

This is a sensitive application in which the sound beam continuously emitted from the transducer crystal is received by a second. Both transducers are encased in one housing (Sanders & Terracciano, 2016). This method is useful for measuring high velocities but its ability to localize a flow signal precisely is limited since the signal can originate at any point along the width or length of the ultrasound beam (Kaddoura, 2009).

f. Pulsed wave Doppler

In pulsed wave Doppler, a Doppler sound beam is sent and received (pulsed) over a short period. This is used to measure the blood flow velocity within a small area at a specified tissue depth (Sanders & Terracciano, 2016). During the study, this was used to assess ventricular in-flow patterns, intracardiac shunts, and to make precise measurements of blood flow at valve orifices.

g. Color-flow mapping

This is used to measure the direction and velocity of blood flow to superimpose a colour pattern. Colour flow mapping was used to measure the velocity and direction of blood flow during the study (Kaddoura, 2009).

2.7 Common echocardiography prognostic markers in patients with cardiomegaly

i. Left ventricular ejection fraction (LVEF)

Lang et al. (2016) describe the assessment of the left ventricular ejection fraction as a cornerstone of risk evaluation and management in cardiac pathology. LVEF is a measurement of the blood that is being pumped out of the left ventricle of the heart, which is the main pumping chamber, with each contraction. Ejection fraction is an indication of left ventricular size. A normal LVEF is from 55-75%. For example, a LVEF of 55% means that 55% of the total amount of blood in the left ventricle is pumped out with each heartbeat. An EF of less than 35% increases the risk of life-threatening causes of sudden cardiac arrest.

The ability of echocardiography to quantify EF, therefore, makes it a good baseline predictor of knowing the cause of cardiomegaly (Hsich, 2014). This makes the use of ECHO an important tool in the management of cardiomegaly, as is the case in this study.

ii. Left ventricular hypertrophy

Left ventricular hypertrophy (LVH) is the thickening of the myocardium of the left ventricle of the heart, frequently referred to as a pathological reaction to cardiovascular disease, or high blood pressure. While LVH itself is not a disease, it is usually a marker for diseases involving the heart which include aortic stenosis, aortic insufficiency and hypertension (Meijs, 2007). Of these diseases marked by LVH, hypertension stands out as a critical risk factor for cardiomegaly. ECHO is used to image the left ventricle. The thickness of the left ventricle as visualized in ECHO correlates with its actual mass. Normal thickness of the left ventricular myocardium is from 0.6 to 1.1 cm as measured at the very end of diastole. If the myocardium is more than 1.1 cm thick, the diagnosis of LVH can be made (Peterson, 2014).

Camici et al (2012) explains that there are two distinct types of left ventricular hypertrophy and these are:

- “physiologic” - this type of hypertrophy is normally found in athletes, and
- “pathologic” - this is a type of LVH which is found in patients with inherited heart muscle pathologies such as hypertrophic cardiomyopathy (HCM) or patients with cardiac and systemic diseases characterized by pressure or volume overload. Patients with pathologic LVH often have symptoms and signs suggestive of myocardial ischemia despite normal coronary angiograms. Under these circumstances ischemia is due to microvascular dysfunction. The abnormalities of coronary microcirculation may be unrelated to the degree of LVH and cause a reduction in maximum myocardial blood flow which, in the absence of epicardial stenosis, is suggestive of microvascular dysfunction. There is no method that enables direct visualization of coronary microcirculation in vivo in humans. Hence, its investigation relies on the measurement of parameters which reflect its functional status, such as myocardial blood flow and coronary flow reserve which is an integrated measure of flow through both the large epicardial coronary arteries and microcirculation.

At the site of this study, its standard practice that a diagnosis of LVH on the ECHO is based on the thickness of the ventricular myocardium.

iii. Mitral Valve Stenosis

One of the uses of ECHO is in the diagnosis of valvular heart disease, particularly mitral stenosis. The mitral valve is found in between the left atrium and left ventricle. The mitral valve opens during ventricular diastole when blood flows from the left atrium into the left ventricle. During ventricular systole, the mitral valve closes as blood is ejected from the left ventricle through the aortic valve (Kaddoura, 2009).

Mitral valve stenosis refers to a narrowing of the mitral valve orifice resulting in impairment of filling of the left ventricle in diastole and is usually caused by rheumatic heart disease. An ECHO may reveal evidence of left atrial enlargement and a more advanced stage of arterial fibrillation or right ventricular hypertrophy consistent with pulmonary hypertension may be present. Characteristic findings of mitral valve stenosis include valve thickening, restricted valve opening and anterior leaflet doming. Transthoracic ECHO also allows assessment of pulmonary artery pressures, detection of other valve disease and visualization of left arterial thrombus (Nashimura, 2014).

Calcifications of the mitral annulus can also be detected on ECHO and is more common in the elderly (Boxt & Abbara, 2016). At the site of this study, transthoracic echocardiography is what is performed at all times and therefore was useful in this study in assessing the occurrence of mitral valve stenosis in cardiomegaly patients.

iv. Mitral regurgitation

Mitral regurgitation (MR) is the leakage of blood from the left ventricle back into the left atrium during systole. It is caused by various mechanisms related to structural or functional abnormalities of the mitral apparatus or the left ventricle. An ECHO may reveal evidence of left arterial enlargement. In more advanced disease, arterial fibrillation or hypertrophy consistent with pulmonary hypertension may be present. Transthoracic ECHO is indicated for all patients with suspected MR to confirm its presence, assess aetiology, and determine its severity (Zoghbi, 2003). The possibility of cardiomegaly is high in MR, therefore the use of ECHO and the CXR played a critical role in assessing how MR affected the heart size. Such findings were of important prognostic significance.

v. Aortic valve stenosis

Aortic valve stenosis is a progressive pathology in which the end-stage is characterized by obstruction of left ventricular outflow, resulting in inadequate cardiac output, decreased exercise capacity, heart failure and death from cardiac causes (Otto & Prendergast, 2014). ECHO has become the key technique for the diagnosis and evaluation of aortic valve stenosis. Most of the clinical decision making are based on ECHO assessment of severity of aortic valve stenosis (Baumgartner et al, 2009). The three cardinal features of aortic stenosis are leaflet thickening, decreased mobility or doming of the leaflets and decrease in size of the valve orifice. In patients with severe aortic stenosis, left ventricular hypertrophy is usually seen (Boxt & Abbara, 2016).

vi. Cardiomyopathy

Cardiomyopathy means disease of the heart. Functionally, the heart has decreased ability to pump blood to the body. The most common types are hypertrophic and dilated cardiomyopathies. In hypertrophic cardiomyopathy, the walls of the heart are abnormally thickened, and the chambers are small. The heart is thus unable to supply adequate blood to the body (Sanders & Terracciano, 2016).

Dilated cardiomyopathy is a heart disorder defined by the presence of a dilated and poorly functioning left ventricle. In this condition, the heart becomes weakened and enlarged. It is characterized by the impaired systolic function of one or both ventricles with normal left ventricular wall thickness (Luscher, 2016). Transthoracic ECHO is indicated for all patients with suspected cardiomyopathy to confirm its presence, assess aetiology, and determine its severity.

i. Aortic root dilation

The dilated aortic root may be linked with underlying aortic valve abnormalities. These anomalies may lead to complications such as aortic dissection, aortic rupture or congestive heart failure from aortic insufficiency. Transthoracic echocardiography is used in serial measurement of aortic root dimensions, proximal aortic segments and consequently used for thoracic aortic aneurism screening (Saura et al, 2017).

ii. Left ventricular dilation

The phyno type of left ventricular dilatation can be the result of a range of pathological conditions such as toxins, infections, or autoimmune diseases. Dilated cardiomyopathy is a disease that is characterized by chamber enlargement and contractile dysfunction of the left ventricle in the absence of chronic pressure and volume overload. ECHO is the first line imaging test in the assessment of patients with dilated left ventricle. It provides important information for diagnosis, stratification and guides treatment (Mathew et al, 2017). At the study site, two- and three-dimension echo was used to analyse and measure the left ventricular chamber size.

iii. Left ventricular diastolic dysfunction

Left ventricular diastolic dysfunction is mostly the result of impaired left ventricular relaxation with or without reduced restoring forces (and early diastolic suction), and increased left ventricle chamber stiffness, which increases cardiac filling pressures. Left ventricular filling pressure should be estimated because elevated left ventricular diastolic pressure in the absence of raised left ventricular end diastolic volume is strong evidence of well-developed diastolic dysfunction. In most clinical studies, left ventricular filling pressures and diastolic function grade can be determined reliably by a few simple ECHO parameters with a high feasibility. Thus, when performing an ECHO, in patients with potential diastolic dysfunction, one should search for signs of impaired LV relaxation, reduced restoring force and increased diastolic stiffness (Nagueh et al., 2016). Diastolic heart failure is a common form of congestive heart failure that is responsible for most morbidity and mortality (Shammas et al., 207). In patients with left ventricular failure, pulmonary hypertension and right ventricular dysfunction are frequent and have an impact on disease progression, morbidity and mortality (Rosentranz et al., 2015). Therefore, in hypertension, activation of the sympathetic nervous system may add not only to the blood pressure elevation but also at the development of left ventricular diastolic dysfunction.

In this study, diastolic function was examined by pulse wave Doppler examination of mitral flow (before and during Valsalva manoeuvre), pulmonary venous flow, and Doppler imaging of the medial mitral annulus.

iv. Left ventricular systolic dysfunction

Left ventricular systolic function is one of the most important prognostic markers of patients with cardiac diseases. It is the most often used parameter of left ventricular systolic function and is measured with two-dimensional (2D) ECHO, by measuring left ventricular end diastolic and end systolic volumes but does not take into consideration ultra-structural changes that may occur at the myocardial level and that may impair left ventricular systolic performance (Tops et al., 2016). At the research site, left ventricular systolic function was examined with the use of 2-D echocardiography.

v. Fractional shortening

The left ventricle ejects its stroke volume during systole using a combination of circumferential and longitudinal shortening associated with twisting of the ventricle. The apex remains relatively stationary; hence, the longitudinal shortening results in mitral annular motion towards the apex. This shortening produces redial thickening causing an inward displacement of the endocardium and a reduction in left ventricular cavity volume. For any given end-diastolic volume, ejection fraction is predominantly determined by absolute wall thickening rather than relative wall thickening (i.e., radial strain). In addition, absolute wall thickening is determined by both end-diastolic wall thickness and redial strain. During diastole, myocardial fibre relaxation, untwisting and lengthening occurs, resulting in ventricular wall thinning during refilling of the ventricle.

Normally, midwall fractional shortening (FS_m) and longitudinal fractional shortening (FS_l) are similar (21%). However, in hypertensive-hypertrophic left ventricular disease, both FS_m and FS_l are significantly reduced despite a normal ejection fraction. In aortic stenosis, FS_l is also reduced while ejection fraction is maintained. There is a reduced FS_m and FS_l in concentric left ventricular hypertrophy despite a normal ejection fraction. Reduced FS_m occurs even though endocardial fractional shortening (FS_{en}) is normal in hypertensive heart disease due to a relatively greater contribution of ventricular wall thickening. In patients with heart failure and preserved ejection fraction, FS_m is significantly lower than in control patients despite mean endocardial fractional shortening not being altered. Concentric left ventricular hypertrophy with a normal ejection fraction is common in heart

failure. A reduced FS_m and FS_l, and yet normal ejection fraction, may be best explained by an increase in end-diastolic wall thickness. Furthermore, epicardial FS (F_{Sep}) is lower and FS_{en} is higher than FS_m (Maclver, 2012)

In this study, M-mode cardiac sonographic two-dimensional, Doppler and 3D echocardiography were all used to assess the function of left ventricle, both during systole as well as in diastole. All modalities of echocardiography were used to assess left ventricular systolic function either quantitatively or qualitatively.

vi. Cardiac chamber size

Heart chamber size dimensions can be determined by two dimensional views to allow quantitative assessment of all the chambers. Quantitative examination of ventricular function is done by estimating the ejection fraction, determined by calculating the change in volume of the ventricle between diastole and systole. Left ventricular size enlargement may be caused by aortic and mitral valve disease, ischemic heart disease, heart failure and dilated cardiomyopathy. Right ventricular enlargement may be due to volume overload from tricuspid or pulmonary regurgitation, right ventricular failure secondary to pulmonary hypertension and cardiomyopathies (Boxt & Abbara, 2016).

Left atrium enlargement may be because of either an increase in arterial pressure resulting from mitral stenosis or elevated left ventricular end-diastolic pressure, an increase in volume as in mitral regurgitation or as a result of primary atrial dysfunction, as in arterial fibrillation. Assessment of the right atrium is mostly made qualitatively by comparing it to the left atrium in the apical four chamber view. Right atrium enlargement can result from multiple conditions including tricuspid regurgitation, pulmonary hypertension and congenital heart defects including atrial septal defects (Boxt & Abbara, 2016).

During this study, heart chamber dimensions were determined by two dimensional views to allow quantitative examination of each chamber.

2.8. Impact of cardiac diseases on households in Zambia

A study carried out to determine the socio-economic impact of cardiac diseases on households in Livingstone, Zambia, established that cardiac diseases like cardiac vascular accidents resulted in the loss of employment, reduced business activity, loss of

income and inability to pay for school fees and rentals (Mapulanga, 2010). Cardiomegaly can thus result in social impacts such as depression, divorce, neglect, fear and apathy within families. These social issues have the potential to further worsen the condition of a patient who suffers from cardiac diseases (like cardiomegaly associated diseases) such that the resulting outcomes make recovery exceedingly difficult. The ability to use imaging studies in determining the possible physical and functional outcome of cardiomegaly patients could assist in planning the alleviation of these resultant social issues, for instance, appropriate counselling and support services.

2.9. Summary of Literature Review

The assessment of the common pathological findings in cardiomegaly patients at LMGH encompasses everything from complete diagnosis of all symptoms and signs of cardiomegaly to the putting in place of interventions to prevent catastrophic consequences of diseases associated with cardiomegaly. Various studies by scholars like Monfared et al. (2015), Tomaszewki (2012), Elliot et al. (2000) and Tavora et al. (2012), have all indicated that there is relative consensus that patients presenting with cardiomegaly should be evaluated with a CXR and an ECHO. The CXR can detect cardiomegaly and any lung infections while an ECHO can help assess the heart and the big vessels to detect the cardiac pathology found in cardiomegaly patients. The CXR and ECHO are important tools in the diagnosis and management of cardiomegaly.

Based on the various findings, by researchers like Monfared et al. (2015), that are obtainable from these imaging studies, it was important to ascertain if a relationship exists between these findings in ascertaining the common pathological findings in patients who present with an enlarged heart on CXR. This was then used to come up with evidence-based decision making on cardiomegaly diagnosis and management.

CHAPTER THREE
METHODOLOGY

The research methods and design for this study involved the selection of the study population, data collection, statistical analysis, organization and interpretation of results and ethical statement. This retrospective study involved the retrieving of data for 124 patients who had cardiomegaly identified on a CXR and had undergone an ECHO examination.

3.1 Study design

The study was a quantitative, retrospective, cross sectional study that was carried out at a single site in Lusaka. It was appropriate to use this design because it enabled the systematic collection, numerical analysis and presentation of data (Muranda, 2004). A retrospective study was used as the data was readily available. Furthermore, this study was descriptive and it involved the collection of information without changing the environment (i.e. nothing was manipulated).

3.2 Research site

The study was undertaken at an academic hospital, in Lusaka, Zambia. Prior, no such formal study had ever been done at this hospital or in Zambia. The research site had a well-established radiological and cardiovascular department with experts in the field that were used for consultation regarding the study.

3.3 Study population

The study population included 124 adult male and female patients who were diagnosed with cardiomegaly on a CXR and had ECHO examinations at the research site.

3.4 Inclusion criteria

The following served as the inclusion criteria:

i. Patients diagnosed with cardiomegaly on PA erect CXR and had a follow up ECHO examination done.
ii. Male and female patient aged between 18 and 80 years.

3.5 Exclusion criteria

. The following served as the exclusion criteria:

i. Patients who did not have cardiomegaly on a CXR
ii. Patients where CXR and/or ECHO reports were not available
iii. Patients who were below 18 years old
iv. Patients who were above 80 years old

3.6 Sample size calculation

The sample size was calculated according to the sample size formula (Isreal, 1992):

$$\boldsymbol{n} = \frac{\boldsymbol{Z}^2(\boldsymbol{p} \times \boldsymbol{q})}{\boldsymbol{e}^2}$$

$\boldsymbol{n}$ = sample size

$\boldsymbol{Z}$ = standard error associated with the chosen level of confidence (1.96)

$\boldsymbol{p}$ = estimated percent in the population (8% as estimated for Zambia by WHO, 2014)

$\boldsymbol{q}$ = 100 – p

$\boldsymbol{e}$ = ± 5 acceptable sample error

$$\boldsymbol{n} = \frac{\boldsymbol{Z}^2(\boldsymbol{p} \times \boldsymbol{q})}{\boldsymbol{e}^2}$$

$$\boldsymbol{n} = \frac{1.96^2(8 \times 92)}{5^2}$$

$$\boldsymbol{n} = \frac{3.8416\ (736)}{25}$$

$$\boldsymbol{n} = 113.2$$

Therefore, a minimum of 113 patients' information was supposed to be retrieved for this study as calculated using 8% as the estimated prevalence rate for cardiovascular diseases in Zambia (WHO, 2014). However, the study included 124 participants. In addition, a convenient sampling method was used. All patients who met the inclusion criteria from the 30th August 2017, dating backwards, formed the sample until the target was reached.

3.7 Data collection

Patients' files were retrieved by the research assistant. Data was retrieved by the researcher, a qualified radiographer, from the retrieved files. Results for the CXR and ECHO were in the form of reports. The results of the CXR and ECHO were entered on data collection sheets (Appendix A and Appendix B). The data collection sheets used for the study had the following sections:

i. Patients demographic information: age and gender
ii. Chest X-ray:
    a. Cardiac thoracic ratio (CTR)
    b. Any lung disease
iii. Echocardiography:
    a. Left and right ventricle
    b. Left and right atrium
    c. Aortic valve (size, systolic and diastolic function)
    d. Inter-ventricular septum (thickness measured in cm)
    e. Posterior wall of the left ventricle (thickness measured in cm)
    f. Mitral valve (regurgitation)
    g. Ejection Fraction (normal: 50-70%)
    h. Pericardial effusion
    i. Colour Doppler
iv. Blood pressure parameters (mm/Hg)

3.8 Data management

Data management involves converting masses of data into smaller, manageable segments. It involves the organization of data from its entry to the research cycle through the dissemination and achieving valuable results (Polit & Beck, 2012). The data collected was coded with the use of specially designed numbers as opposed to individual names (see appendix A & B).

The data collected was in the care of the principal investigator and was kept on collection sheets (see appendix A & B) which were locked in a safe box in the office of the head of

the radiology department at the study site. Keys for the safe box were kept by the principal investigator and a spare key was given to the head of the radiology department.

The data will remain stored for the appropriate number of years required by the academic and health institutions (study site) after graduation and subsequent publications of articles. Individuals not involved in the study did not have access to the raw data collected. Only the principal investigator, registry clerk (who was used as a research assistant), the head of the radiology department, the supervisor and the statistician had access to the collected data.

3.9 Data analysis

The data was captured on a data spread sheet that was designed by the researcher. The data was quality controlled, assured and analysed by a statistician using SPSS version 24. Descriptive statistics (mean, median, percentages, standard deviation and variance) were used for prevalence in age, gender and pathological conditions.

Inferential statistics were also used with a level of statistical significance set at $p<0.05$. Spearman's correlation test was conducted to assess the relationship between age and cardiomegaly. Chi-squared test was used to assess whether there was a significant association between 2 sets of variables (Willis, 2004) e.g. gender and cardiomegaly, Doppler findings and cardiomegaly, cardiac conditions, and blood pressure readings.

3.10 Data validity and reliability

The following aspects of data validity and reliability were applied to this research study:

i. Validity

According to Watkins (2012), validity is concerned with the extent to which the research findings accurately represent what is happening or more specifically, whether the information is a true picture of what is being studied. According to Cooper and Schindler (2006), three major forms of validity can be identified. These are 'content validity', 'criterion-related validity' and 'construct validity'. The appropriate research design, research methodology and the right data collecting tools (as explained in the appropriate corresponding headings) were used in this study to ensure validity. The data collecting

sheets, which were verified by the radiologist and cardiologist, (appendix A & B) contains sections that were used to meet the objectives of the study.

ii. Reliability

Reliability (sometimes referred to as trustworthiness), is concerned with the findings of the research (Watkins, 2012). The findings are considered reliable if the research is repeated and similar results are obtained. This can be achieved by repeating the same research (at any similar institution), using similar tools and appropriate expert personnel. For reliability, it is expected that similar results would be obtained.

3.11 Ethics

According to Watkins (2012) in research, ethics refers to the appropriateness of your behaviour about the rights of those who become the subject of your work, or are affected by it. Ethics provides rules and guidelines to the researcher about behavioural expectations and the expected conducts towards participants in the study, co-researchers, research assistants, fieldworkers, institution and sponsors.

Therefore, before conducting this research, a research proposal was submitted to the Cape Peninsula University of Technology's Ethics Committee for approval. A copy of the proposal and ethical approval (appendix E) were then submitted to the study site, head of the institution, to seek permission to conduct the study at their site. Thus, this research was conducted according to the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Being a retrospective study, particular attention was paid to issues of confidentiality by ensuring that all information that came into the possession of the researcher, research supervisor, head of the radiology department and research assistant during the study was not shared with any unauthorized person. To help achieve this, the patient's names were not used in this study and each patient's file was assigned a code. Additionally, the people involved in this study were informed of the need to ensure confidentiality and were given an information leaflet about the research (appendix C). People involved in this research played the following roles:

i. The research assistant assisted in retrieving files. The research assistant was a qualified registry clerk.

ii. The research supervisor and co-supervisor assisted the researcher on how to go about the research.
iii. The statistician analysed the data.
iv. The cardiologist who managed the patient was approached to explain some unfamiliar conditions.
v. The radiologist responsible for reporting the CXR images and conducting the ECHO was approached to explain some conditions.
vi. The head of the radiology department at the study site ensured that the researcher and his team were accorded a conducive environment to conduct the study.

The researcher did not request informed consent from patients as the study was retrospective. However, additional permission to allow the researcher to research the study site was obtained from the Medical Superintendent (appendix D and E) at Levy Mwanawasa General Hospital.

By adhering to strict confidentiality of data retrieved, no harm was done to the patients (non-maleficence). There may be no direct benefit for the patients as this is a retrospective study, however, the outcome of the study will be published, and this may assist in improving patient management in cardiac disease.

CHAPTER FOUR

PRESENTATION OF FINDINGS

4.1 Introduction

A total of 124 patients' files were retrieved for this research study. These files were for patients in whom cardiomegaly was revealed by chest radiographs and had undergone an echocardiography examination at Levy Mwanawasa Hospital in Lusaka. For statistical analysis purposes, the information obtained from the files was converted into numerical data. This study focused on establishing the association between cardiomegaly diagnosed on the CXR to the ECHO findings of the same patient. Statistical software SPSS-v24 (2017) with CI: 95% was used. The normal and abnormal findings were assessed based on the discussions in the literature review.

4.2 Gender distribution in cardiomegaly

The data was collected from a sample of 124 patients. Of these, 84 were females and 40 were male; representing a distribution of 67.7% women and 32.3% men as depicted in Table 1 below.

Table 1: Gender distribution in cardiomegaly

		Frequency	Percent
Valid	Male	40	32.3
	Female	84	67.7
	Total	124	100.0
Missing	System	1	
Total		125	

4.3 Age distribution in cardiomegaly

Table 2: Age distribution in cardiomegaly

Age (years)		Frequency	%
Valid	18 - 29	26	21.0
	30 - 45	10	8.1
	46 - 60	12	9.7
	60 - 64	17	13.7
	65 - 74	33	26.6
	75 - 80	26	21.0
	Total	124	100.0
Missing	System	1	
Total		**125**	

Table 3: Descriptive analysis of age distribution in cardiomegaly

	Age (years) n = 124
Mean	56.78
Median	63.00
Mode	80
Std. Deviation	18.382
Variance	337.912
Range	62
Minimum	18
Maximum	80

The results in Table 1 - 3 show some critical characteristics of the patients in the sample in terms of their age. Firstly, the results show the mean age of about 56.78 years,

indicating the average age of the participants. In addition, the median age was 63 years indicating that there is an equal probability that if the sample was halved, 50% would fall above and the other 50% below. This also implies that the population was not young. The age of highest frequency in this study was 80 years, being the mode. The smallest age from the participants was 18 years and the oldest was 80 years, giving the range of 62. The standard deviation and the variance show how patients' age deviated from the mean and one another respectively.

4.4 Cardiomegaly

Cardiomegaly, determined by the cardiothoracic ratio, was a key determinant for patient participation in the study. The severity of the condition for all patients was obtained and the frequency table below is the summary of the results.

4.4.1 The severity of cardiomegaly

Table 4 below shows that 53.2% had severe cardiomegaly. On the other hand, 32.3% had moderate cardiomegaly while 14.5% had minimal cardiomegaly.

Table 4: Cardiomegaly by severity

		Frequency	Percent
Valid	Minimal	18	14.5
	Moderate	40	32.3
	Severe	66	53.2
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.4.2 Cardiomegaly and age

Table 5 below shows that as the age of the patients increases, the severity of the condition also worsens. Specifically, more patients from the young age group <35 years (n=8) were found to have minimal cardiomegaly while more in the older age group >75 years (n=30) were found to have the severe condition.

Table 5: The severity of cardiomegaly by age groups

AGE RANGE (years)	CARDIOMEGALY			
	Minimal	**Moderate**	**Severe**	**Total**
Less than 35	8	9	3	**20**
35-45	1	13	6	**20**
46-54	3	2	7	**12**
55-64	2	9	6	**17**
65-74	3	2	14	**19**
75+	1	5	30	**36**
Total	**18**	**40**	**66**	**124**

The correlation between cardiomegaly and age

The relationship between cardiomegaly and the age of patients was computed to identify any pattern. This involved the use of Pearson's Rank Correlation (r). As r > 0.5, i.e. r = 0.58, it is considered a strong positive correlation.

Table 6: Correlation between cardiomegaly and age *(p<0.05)*

Pearson Correlation		Cardiomegaly	Age
	Cardiomegaly	1	0.58
	Age	0.58	1

4.4.3 Cardiomegaly and gender

Table 7: The severity of cardiomegaly and gender

		Gender	
		Male	**Female**
Cardiomegaly	Minimal	5	13
		12.5%	15.5%
	Moderate	15	25
		37.5%	29.8%
	Severe	20	46
		50.0%	54.8%
Total		40	84
		100.0%	100.0%

The Chi-square test was conducted to assess the significance of the relationship between cardiomegaly and gender testing the null hypothesis that cardiomegaly is non-gender selective. Pearson's Chi-square test yielded a p-value of 0.676 which is far greater than the standard 0.05 level of significance, thus leading to the acceptance of the null hypothesis. Therefore, there is no sufficient evidence to suggest an association between gender and cardiomegaly. This is supported by the evidence in the table below which shows that at every level of severity of cardiomegaly, both women and men were affected. This, therefore, leads to the conclusion that both females and males were at risk to cardiomegaly.

Table 8: The Chi-square test across gender and cardiomegaly (*p<0.05)*

	Value	**Df**	**p-value**
Pearson Chi-Square	.784	2	.676
Likelihood Ratio	.777	2	.678
Linear-by-Linear Association	.016	1	.899
N of Valid Cases	124		

4.4.4 Normal and abnormal ECHO findings in cardiomegaly

Table 9 below shows that 87.9% of patients with cardiomegaly had an abnormal ECHO finding while 12.1% showed normal ECHO reading. This means that 87.9% of patients with cardiomegaly diagnosed on chest X-ray had one or more cardiovascular diseases accompanying the cardiomegaly.

Table 9: Normal and abnormal ECHO findings in cardiomegaly

		Frequency	Percent
Valid	Normal	15	12.1
	Abnormal	109	87.9
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.5 Common diseases identified in the study

Table 10 displays some of the diseases which were common in the study. As the results indicate, left ventricular diastolic dysfunction was the most common disease found in the study population. Left ventricular diastolic dysfunction was found in more than half of the study participants (71%). Thus, left ventricular diastolic dysfunction was the overall most common disease among the patients. Other common diseases include left atrium dilation and left ventricular systolic dysfunction, with 29% distribution each.

Table 10: Common diseases found in cardiomegaly

DISEASE	PERCENT OF OCCURRENCE		
	Seen	Not seen	Total
Cardiomyopathy	16	84	100
Inter Ventricular Hypertrophy	23	77	100
Left Atrium Dilation	29	71	100
Left Ventricular Diastolic Dysfunction	71	29	100
Left Ventricular Dilation	21	79	100
Left Ventricular Hypertrophy	24	76	100
Left Ventricular Systolic Dysfunction	29	71	100
Pericardial Effusion	21	79	100
Pulmonary Hypertension	16	84	100
Right Atrium Dilation	25	75	100
Right Ventricular Dilation	18	82	100

4.6 Cardiac disease distribution by gender

Table 11 below shows the prevalence of diseases based on gender. Some of the diseases with high prevalence among males include left ventricular diastolic dysfunction (65%), right atrium dilation (32.5%) and left atrium dilation (37.5%). Among female patients, left ventricular systolic dysfunction (26.2%), left ventricular hypertrophy (23.8%), left atrium dilatation (23.8%) and left ventricular diastolic dysfunction (73.8%) were among the common diseases. However, left ventricular diastolic dysfunction is the most common in both males and females.

Table 11: Common cardiac diseases found by gender

DISEASE	MALE			FEMALE		
	Seen	Not seen	Total	Seen	Not seen	Total
Cardiomyopathy	10	30	**40**	9	75	**84**
Inter Ventricular Hypertrophy	11	29	**40**	17	67	**84**
Left Atrium Dilation	15	25	**40**	20	64	**84**
Left Ventricular Diastolic Dysfunction	26	14	**40**	62	22	**84**
Left Ventricular Dilation	13	27	**40**	12	72	**84**
Left Ventricular Hypertrophy	9	31	**40**	20	64	**84**
Left Ventricular Systolic Dysfunction	14	26	**40**	22	62	**84**
Pericardial Effusion	4	36	**40**	7	78	**84**
Pulmonary Hypertension	6	34	**40**	13	71	**84**
Right Atrium Dilation	13	27	**40**	17	67	**84**
Right Ventricular Dilation	11	29	**40**	11	73	**84**

4.7 Blood pressure in cardiomegaly

After testing for blood pressure, the result indicated that 42.7% of the patients had severe blood pressure, 14.5% had moderate blood pressure while 12.9% had minimal. Normal blood pressure was shown in 29,8% of the patients (Table 12).

Table 12: Blood pressure in cardiomegaly

Blood Pressure (mm Hg)		Frequency	Percent
Valid	up to 120/60-80	37	29.8
	121-140/81-90 (minimal)	16	12.9
	141-159/91-99 (moderate)	18	14.5
	151 or more/100 or more (severe)	53	42.7
	Total	124	100.0
Missing	System	1	
Total		125	

4.8 Variations in blood pressure and cardiac conditions found on ECHO

The blood pressure of patients with various conditions was tested and results showed that most of the patients with cardiac diseases had severe blood pressure. There was a significant association between severe blood pressure and cardiomyopathy *(p = 0.023),* inter-ventricular hypertrophy *(p = 0.017),* left atrium dilation *(p = 0,007),* left ventricular diastolic dysfunction (*p = 0.045),* left ventricular dilation *(p = 0.003),* left ventricular hypertrophy (*p = 0,028),* left ventricular systolic dysfunction *(p = 0.048)* and pericardial effusion *(p = 0,001)* (Table 12). On the other hand, conditions like pulmonary hypertension, right atrium dilation and right ventricular dilation were associated with normal blood pressure.

Table 13: The relationship between common cardiac diseases and blood pressure (Chi-squared test, *$p<0.05$*)

DISEASE	Severity of Blood Pressure in patients with disease	*p-value*
Cardiomyopathy	Generally Severe	*0.023**
Inter Ventricular Hypertrophy	Generally Severe	*0.017**
Left Atrium Dilation	Generally Severe	*0.007**
Left Ventricular Diastolic Dysfunction	Generally Severe	*0.045**
Left Ventricular Dilation	Generally Severe	*0.003**
Left Ventricular Hypertrophy	Generally Severe	*0.028**
Left Ventricular Systolic Dysfunction	Generally Severe	*0.048**
Pericardial Effusion	Generally Severe	*0.001**
Pulmonary Hypertension	Generally Normal	*0.044**
Right Atrium Dilation	Generally Normal	*0.006**
Right Ventricular Dilation	Generally Normal	*0.009**

4.9 Doppler ultrasound results

Doppler readings of cardiac cycles were used to evaluate the blood flow of patients in the study. At the mitral valve, recordings of the peak velocity (E) and the peak atrial velocity (A) were analysed. The Doppler results showed 60% of patients in the sample had increased blood flow and 6% had severely increased blood flow. On the other hand, 22% of patients showed normal blood flow. However, blood flow could not be measured on 12% of patients in the sample because of the absence of the A-wave (Table 14).

The results in Table 15 showed that increased blood flow was significantly associated with minimum (*$p=0.002$*), moderate (*$p=0.000$*) and severe (*$p=0.04$*) cardiomegaly. Severely increased blood flow was significantly associated with severe cardiomegaly (*$p=0.004$*).

Table 14: Doppler ultrasound results

Doppler Results	Frequency	Percentage
Normal Blood Flow	27	22%
Increased Blood Flow	75	60%
Severely Increased Blood Flow	7	6%
Blood Flow not measured due to the absence of the A-wave	15	12%
Total	**124**	**100%**

Table 15: The distribution and relationship between cardiomegaly and Doppler *(Chi-squared test p<0.05*)*

Cardiomegaly	**Doppler test (blood flow results)**				
	Normal	Increased blood flow	Severely increased blood flow	Not tested	**Total**
Minimal	*5(0.048*)*	*9(0.002*)*	*1(0.110)*	*3*	***18***
Moderate	*15(0.008*)*	*20(0.000*)*	*2(0.701)*	*3*	***40***
Severe	*7(0.025*)*	*46(0.040*)*	*4(0.004*)*	*9*	***66***
Total	***27***	***75***	***7***	***15***	***124***

4.10 Cardiac abnormalities found on ECHO

4.10.1 Aortic root dilation

A normal aortic root diameter was shown in 91.1% of patients, while 4.8% had minimally dilated, 2.4% had moderately dilated and 1.6% had severely dilated aortic root diameter.

Table 16: Aortic root dilatation in cardiomegaly

Aortic root diameter (mm)		Frequency	Percent
Valid	up - 30 mm (normal)	113	91.1
	31 - 33 mm (minimum)	6	4.8
	34 - 36 mm (moderate)	3	2.4
	37 mm or more (severe)	2	1.6
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.2 Left atrial dilation

A normal left atrial diameter was shown in 71% of patients while 10.5% had minimally dilated, 11.3% moderately dilated and 7.3% had severely dilated atrial diameter.

Table 17: Left atrial dilation in cardiomegaly

Left atrial diameter (mm)		Frequency	Percent
Valid	up to 38 mm (normal)	88	71.0
	39 - 42 mm (minimal)	13	10.5
	43 - 46 mm (moderate)	14	11.3
	47 mm or more (severe)	9	7.3
	Total	124	100.0

4.10.3 Left ventricular dilation

A normal left ventricular diameter was shown in 79.8% of the patients, 6.5% had minimally dilated left ventricle, 9.7% moderate while 4% had severely dilated left ventricle diameter.

Table 18: Left ventricular dilation in cardiomegaly

Left ventricular diameter (mm)		Frequency	Percent
Valid	up to 53 mm (normal)	99	79.8
	54 - 57 mm (minimal)	8	6.5
	58 - 61 mm (moderate)	12	9.7
	62 mm or more (severe)	5	4.0
	Total	124	100.0
Missing	System	1	
Total		125	

4.10.4 Fractional shortening

Normal fractional shortening was reported in 68.5% of patients; 3.2% had minimal, 21.8% moderate and 6.5% had severe fractional shortening.

Table 19: Fractional shortening in cardiomegaly

Fractional shortening		Frequency	Percent
Valid	27 - 45% (normal)	85	68.5
	22 - 26% (minimal)	4	3.2
	17 - 21% (moderate)	27	21.8
	16% or less (severe)	8	6.5
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.5 Mitral valve regurgitation

No mitral valve regurgitation was reported in 83.1% of patients, while16.9% had minimal mitral valve regurgitation.

Table 20: Mitral valve regurgitation in cardiomegaly

Mitral valve regurgitation		Frequency	Percent
Valid	Normal	103	83.1
	Minimal regurgitation	21	16.9
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.6 Inter-ventricular septal thickness

Normal inter-ventricular septal thickness was reported in 77.4% of patients; 17.7% had minimally thickened, while 4% had moderate and 0.8% had severely thickened inter-ventricular septum.

Table 21: Inter-ventricular septal thickness in cardiomegaly

Inter-ventricular septal thickness (mm)		Frequency	Percent
Valid	6 - 11 mm (normal)	96	77.4
	12 - 14 mm (minimal)	22	17.7
	15 - 17mm (moderate)	5	4.0
	18 mm or more (severe)	1	.8
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.7 Posterior wall thickness

Normal posterior wall thickness was reported in 76.6% of patients; 20.2% had minimally thickened wall, while 2.4% had moderate and 0.8% had severely thickened posterior wall.

Table 22: Posterior wall thickness in cardiomegaly

Posterior wall thickness (mm)		Frequency	Percent
Valid	6 - 11 mm (normal)	95	76.6
	12 - 14 mm (minimal)	25	20.2
	15 - 17mm (moderate)	3	2.4
	18 mm or more (severe)	1	.8
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.8 Right ventricular outflow tract

Normal right ventricular outflow tract was reported in 83.1% of patients; 8.9% had minimal, while 4% hade moderate and 4% had severe right ventricular outflow tract.

Table 23: Right ventricular outflow tract and cardiomegaly

Right ventricular outflow tract		Frequency	Percent
Valid	up to 29 mm (normal)	103	83.1
	30 – 32 mm (minimum)	11	8.9
	33 – 35 mm (moderate)	5	4.0
	36 mm or more (severe)	5	4.0
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.9 Ejection fraction

Normal ejection fraction was reported in 63.7% of patients, 8.9 had minimal, while 24.2% had moderate and 3.2% had severe ejection fraction.

Table 24: Ejection fraction and cardiomegaly

Ejection fraction		Frequency	Percent
Valid	55 - 75% (normal)	79	63.7
	45 - 54% (minimal)	11	8.9
	30 - 44% (moderate)	30	24.2
	29% or less (severe)	4	3.2
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.10 Thrombus

No thrombus was detected in any of the patients.

4.10.11 Aortic root regurgitation

No aortic valve regurgitation was reported in 94.4% of patients; 0.8% had minimal, while 4% hade moderate and the other 0.8% had severe aortic valve regurgitation.

Table 25: Aortic root regurgitation

Aortic root regurgitation		Frequency	Percent
Valid	Not seen	117	94.4
	Minimal	1	.8
	Moderate	5	4.0
	Severe	1	.8
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.12 Calcified aortic valve

No aortic calcifications were reported in 97.6% of patients while 2.4% had aortic calcifications.

Table 26: Calcified aortic valve and cardiomegaly

Calcified aortic valve		Frequency	Percent
Valid	Not seen	121	97.6
	Seen	3	2.4
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.13 Cardiomyopathy

No cardiomyopathy was reported in 84.7% of patients, while 15.3% had cardiomyopathy.

Table 27: Cardiomyopathy and cardiomegaly

Cardiomyopathy		Frequency	Percent
Valid	Not seen	105	84.7
	Seen	19	15.3
	Total	124	100.0
Missing	System	1	
Total		125	

4.10.14. Cor pulmonale

No cor pulmonale was reported in 97.6% of patients, while 2.4% had cor pulmonale.

Table 28: Cor pulmonale and cardiomegaly

Cor pulmonale		Frequency	Percent
Valid	Not seen	121	97.6
	Seen	3	2.4
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.15 Inferior vena cava

A normal inferior vena cava diameter was reported in 99.2% of patients while only 0.08% had dilated inferior vena cava.

Table 29: Inferior vena cava dilation and cardiomegaly

IVC dilation		Frequency	Percent
Valid	Not seen	123	99.2
	Seen	1	.8
	Total	124	100.0
Missing	System	1	
Total		**125**	

.

4.10.16 Left atrium dilation

A normal left atrium chamber size was reported in 71.8% of patients, while 28.2% had left atrium dilation.

Table 30: Left atrium dilation and cardiomegaly

Left atrium dilation		Frequency	Percent
Valid	Not seen	89	71.8
	Seen	35	28.2
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.17 Left diastolic dysfunction

Abnormal left ventricular diastolic function was reported in 71% of patients, while 29% were normal.

Table 31: Left ventricular diastolic dysfunction and cardiomegaly

Left ventricular diastolic dysfunction		Frequency	Percent
Valid	E/A > 1	36	29.0
	E/A < 1	88	71.0
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.18 Mitral valve degeneration

No mitral valve degeneration was reported in 96.8%, while 3.2% had mitral valve degeneration.

Table 32: Mitral valve degeneration and cardiomegaly

Mitral valve degeneration		Frequency	Percent
Valid	Not seen	120	96.8
	Minimal	4	3.2
	Total	124	100.0
Missing	System	1	
Total		125	

4.10.19 Mitral valve regurgitation

No mitral valve regurgitation was reported in 84.6% of patients, while 5.7% had minimal, 6.5% moderate and 3.3% had severe mitral valve regurgitation.

Table 33: Mitral valve regurgitation and cardiomegaly

Mitral valve regurgitation		Frequency	Percent
Valid	Not seen	104	84.6
	Minimal	7	5.7
	Moderate	8	6.5
	Severe	4	3.3
	Total	123	100.0
Missing	System	2	
Total		**125**	

4.10.20 Myocardial infarction

No myocardial infarction was reported in 96% of patients, while 4% had a myocardial infarction.

Table 34: Myocardial infarction and cardiomegaly

Myocardial infarction		Frequency	Percent
Valid	Not seen	119	96.0
	Seen	5	4.0
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.21 Pericardial effusion

Pericardial effusion was reported in 21% of patients, while 79% had no pericardial effusion.

Table 35: Pericardial effusion and cardiomegaly

Pericardial effusion		Frequency	Percent
Valid	Not seen	98	79.0
	Seen	26	21.0
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.22 Pleural effusion

Pleural effusion was reported in 8.1% of patients, while 91.9% had no pleural effusion.

Table 36: Pleural effusion and cardiomegaly

Pleural effusion		Frequency	Percent
Valid	Not seen	114	91.9
	Seen	10	8.1
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.23 Pulmonary hypertension

Pulmonary hypertension was reported in 15.3% of patients, while 84.7% had no pulmonary hypertension.

Table 37: Pulmonary hypertension and cardiomegaly

Pulmonary hypertension		Frequency	Percent
Valid	Not seen	105	84.7
	Seen	19	15.3
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.24 Right atrium dilation

A dilated right atrium was reported in 24.2% of patients, while 75.8% of the patients had normal chamber size of the right atrium.

Table 38: Right atrium dilation and cardiomegaly

Right atrium dilation		Frequency	Percent
Valid	Not seen	94	75.8
	Seen	30	24.2
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.25 Right ventricular dilation

A dilated right ventricle was reported in 17.7% of patients, while 82.3% had normal chamber size of the right ventricle.

Table 39: Right ventricular dilation and cardiomegaly

Right ventricular dilation		Frequency	Percent
Valid	Not seen	102	82.3
	Seen	22	17.7
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.26 Tricuspid degeneration

No patients had tricuspid valve degeneration.

4.10.27 Tricuspid valve regurgitation

Tricuspid valve regurgitation was reported in patients as follows: 9.7% (minimal regurgitation), 11.3% (moderate) and 4.8% (severe regurgitation).

Table 40: Tricuspid valve regurgitation and cardiomegaly

Tricuspid valve regurgitation		Frequency	Percent
Valid	Not seen	92	74.2
	Minimal	12	9.7
	Moderate	14	11.3
	Severe	6	4.8
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.28 Paradoxical motion of the IVC

A paradoxical motion of the IVC was reported in 1.6% of patients, while 98.4% had no paradoxical motion of the IVC.

Table 41: Paradoxical motion of the IVC and cardiomegaly

Paradoxical motion of IVC		Frequency	Percent
Valid	Not seen	122	98.4
	Seen	2	1.6
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.10.29 Paradoxical septal motion

No paradoxical septal motion was reported in 99.2%, while 0.8% had paradoxical septal motion.

Table 42: Paradoxical septal motion and cardiomegaly

Paradoxical septal motion		Frequency	Percent
Valid	Not seen	123	99.2
	Seen	1	.8
	Total	124	100.0
Missing	System	1	
Total		**125**	

4.11 Summary of results

The study population *(n = 125*) were all diagnosed with cardiomegaly by measurement of the cardio-thoracic ratio on the CXR. Cardiomegaly was more prevalent in females (67.7%) compared to males (32.3%). All age groups were affected, however, the prevalence increased with age; 60% of the patients were aged 60-80 years. More than 50% of the cardiomegaly cases were severe. There was no significant difference between males and females with severe cardiomegaly.

The ECHO findings showed left ventricular diastolic dysfunction as the most common disease (71%) followed by left ventricular systolic dysfunction (29%) and left atrium dilation (29.1%). Doppler ultrasound revealed a significant association between severe cardiomegaly and severely increased blood flow patterns (*p=0.004*); and between cardiomegaly (minimal, moderate and severe) and increased blood flow patterns (*p=0.002, p=0.000* and *p=0.04* respectively). Other abnormal ECHO findings included: ejection fraction (36.3%), fractional shortening (31.5%), left atrial dilation (28.2%), tricuspid valve regurgitation (25.8%), right atrium dilation (24.2%), posterior wall thickness (23.4%), interventricular septal thickness (22.5%), pericardial effusion (21%), left ventricular dilation (20.2%), left ventricular dilation (17.7%), right ventricular outflow tract (16.9%), minimum right ventricular outflow tract (16.9%), mitral valve regurgitation (15.5%), aorta root dilation (8.8%) and pleural effusion (8.1%)

There was a significant association between severely increased blood pressure and cardiomyopathy *(p=0.023*), interventricular hypertrophy (*p=0.017*), left atrial dilation (*p=0.007*), left ventricular diastolic dysfunction (*p=0.045*), left ventricular dilation (*p=0.003*), left ventricular hypertrophy (*p=0.028*), left ventricular systolic dysfunction (*p=0.048*) and pericardial effusion (*p=0.001*).

Results showed a significant association (*p<0.05*) between cardiomegaly diagnosed on the CXR and abnormal findings on the ECHO.

CHAPTER FIVE
DISCUSSION AND CONCLUSION

5.1 Introduction

In this chapter, emphasis is placed on those results that answer the research questions in general and those that meet the aim and specific objectives of this study.

Studies have confirmed that cardiomegaly is very prominent globally and the CXR and ECHO have been used to prove this fact. A study in Iraq from 2006 to 2007, found 24.9% and 50.8% of patients had cardiomegaly on CXR and ECHO respectively (Monafred et al., 2015). Tomaszewski (2012) estimated that cardiomegaly is found in 5-7% of CXR in tropical Africa. Tavora et al. (2012) discovered that among adults with a mean age of ±50 years, cardiomegaly is a frequent cause of sudden cardiac death. At the research site in Zambia, the prevalence of cardiomegaly was estimated to be at 16.7%, as shown by records from the X-ray department register (LMGH, 2015). It should be noted that most cardiovascular diseases are very often accompanied by an enlarged heart. Therefore, cardiovascular diseases are very common in patients with cardiomegaly. Considering all the complications to the human body due to this disease, cardiomegaly is a disease of great concern worldwide. Drawing on the findings of this study, this chapter presents a discussion on the association between cardiomegaly diagnosed on the CXR and the ECHO results of the same patients. This study provides evidence that there is a strong association between cardiomegaly diagnosed on a CXR and the ECHO results of the same patient.

5.2 Cardiomegaly findings

The main objective of this study was to establish whether there was an association between the CXR reports of patients diagnosed with cardiomegaly to the ECHO reports of the same patients. Cardiomegaly is an independent prognostic factor for mortality, and increased CTR, which is associated with poor prognosis in older patients.

Hypertrophy determined by ECHO is associated with 1.5 to 4 times increase in mortality, which is indicative of great importance and necessity of early diagnosis, especially in old or middle-aged patients as the results from the preceding chapter showed. Cardiomegaly

could result in mortality due to some mechanisms such as higher oxygen need by larger ventricular mass, fatal ventricular arrhythmias, and endothelial dysfunction (Elhendy et al., 2003).

The results of this study show that more than half of the cardiomegaly patients (53%) had severe cardiomegaly. On the other hand, 32 percent had moderate while 15 percent had minimal cardiomegaly. Of all the patients with cardiomegaly diagnosed by the CTR on the CXR, only 12% had normal ECHO findings while 88% had one or more cardiovascular disease accompanying the cardiomegaly.

The study results also show that most conditions of cardiomegaly such as cardiomyopathy (15.3% prevalence), pulmonary hypertension (15.3% prevalence) and left atrium dilation (28.2% prevalence) were present in patients. These findings are consistent but lower than the conclusions reached by other scholars such as Tomaszewski (2012) who concluded that 21.76% patients in Nigeria who had cardiomegaly on a standard CXR also had severe cardiomyopathy while figures from Senegal and Ivory Coast were lower than the research findings and ranged from 7.2 to 57%.

Furthermore, in Monfared et al. (2015) study, CTR was considered as the most effective measurement in CXR to detect cardiomegaly, which has the minimum false positive in comparison with the transverse and longitudinal diameter of the heart and lungs.

But, although CTR is an important tool in the clinician's armamentarium in the diagnostic and therapeutic management of patients, from these results it can be said that echocardiography is commonly superior to chest radiography in providing a better assessment of cardiomegaly and clearly demonstrated better sensitivity and specificity for that purpose.

5.3 Risk by age

Our study showed a significant difference between CTR in patients' ages. It demonstrated that older patients are more at risk. It should be noted that cardiomegaly found in CXR correlates with 1.84 times increase in mortality. Specifically, more patients from the young age group (<35) were found to have minimal cardiomegaly while more in the older ages (>75) were found to have the severe condition. The study also showed that the number

of respondents increased as their age increases. Thus there is a positive and strong correlation between the condition and the age as the older the patients, the more the number of patients and the more severe was their cardiomegaly.

These findings confirm with scholars like Lavie et al. (2009), Artham et al. (2009) and Screaton et al. (2010), who all agree that enlarged heart size is an independent predictor of death, and an increased cardiothoracic ratio (CTR) on a CXR, irrespective of its aetiology, is associated with poor prognosis in middle-aged patients. This issue is thus indicative of great importance and necessity of early diagnosis, especially in older patients.

But, Scoot explains that the indication of cardiovascular disease in young patients with cardiomegaly is non-significant. He indicates that incidental findings of cardiomegaly in children, of an abnormal cardiac silhouette with no underlying cardiac symptoms or signs, is not associated with an underlying structural or functional heart disease (Scoot et al.,2018).

5.4 Risk by gender

From the results in the preceding chapter, it is worth concluding that there was no association between the gender of an individual and the risk of acquiring cardiomegaly. For both minimal and severe categories, both males and females were seen to be at risk of acquiring cardiomegaly. That is, there is an equal chance that either females or males may have cardiomegaly. This was confirmed by the Chi-square results at 5% level of significance, whose p-value was found to be 0.676.

5.5 Disease distribution in cardiomegaly

The results from this study showed that left ventricular diastolic dysfunction was the most prevalent disease in patients with cardiomegaly. It was found in more than half of the study participants (71%). Other common cardiovascular conditions included left atrium dilation and left ventricular systolic dysfunction, with 29% distribution each, right atrium dilatation (25%), left ventricular hypertrophy (24%), interventricular hypertrophy (23%), and left ventricular dilatation and pericardial effusion at 21% each. This is in contrast to a study conducted by Ryszard (2012) on 170 patients, at the Madonna University Teaching Hospital in Nigeria. In his study, cardiomegaly was revealed by chest radiographs and patients then underwent echocardiography. Arterial hypertension was found to be most

frequently associated cardiomegaly (39.4%), followed by dilated cardiomyopathy (21.76%), endomyocardial fibrosis (14.1%) and valvular defects (9.4%).

In addition, 70% of the patients in this study had increased blood pressure with 43% of the patients having severely increased blood pressure. The test results also showed that 66% of patients in the sample had increased blood flow on Doppler ultrasound, with the blood flow of 6% of the patients being severely increased. Patients with increased blood flow showed an increase in blood pressure with those with severely increased blood flow showing a strong positive association with severe high blood pressure.

5.6 Limitation of the study

Being a retrospective study, there were challenges in accessing information or clinical data that could have been relevant to this study. This was due to the fact that the data used in this study could only be collected from patients' records as they appeared which in some cases could not be found or was incomplete. As such, no measurements of gradient of stenosis and for the aorta were available on the ECHO reports. In addition, the inferior vena cava (IVC), right atrium and right ventricle measurements were also not available as the ECHO reports only mentioned whether the IVC was dilated or not without indicating the actual values. Furthermore, Doppler reports on the ECHO were only indicating the E/A value without the actual velocity of the blood flow. In future, it will be necessary to therefore carry out a longitudinal prospective study that will take into consideration the issues of quantification of all findings.

5.7 Recommendations

The researcher would like to recommend that cardiomegaly diagnosed on a chest X-ray should be considered as a strong indicator for cardiovascular diseases. Therefore, all patients diagnosed with cardiomegaly should be assessed further with ECHO, as this study has shown that there is a significant association between cardiomegaly diagnosed on a CXR and many of the ECHO results.

In addition, it is recommended that those from 65 years and above should be made aware that they are more at risk of cardiomegaly and thus cardiovascular diseases. This research showed that there are more patients in these age groups, between 65 to 74 years and those above 75 years.

Furthermore, it is recommended that more research be done on cardiovascular diseases like left ventricular diastolic dysfunction, left atrium dilatation, left ventricular systolic dysfunction and left ventricular hypertrophy, as these were found to be quite common as well as severe in patients with cardiomegaly. More preventive measures against these diseases should also be put in place.

The researcher would also like to recommend that all patients with a raised blood pressure should undergo a CXR and ECHO examination to assess for any other specific cardiovascular diseases like cardiomyopathy, left atrium dilatation, left ventricular hypertrophy and pericardial effusion. These diseases were found to be severe in patients with a raised blood pressure in this study.

REFERENCES

1. Aksut, B. 2015. *Dilated and Restrictive Cardiomyopathies. Diabetes and Obesity Summit Presentation*. Hawaii: Cleveland Clinic Foundation in Honolulu.
2. Artham, M., Lavie, J., Milani, V., Patel. A., Verma, A., & Ventura, O. 2009. Clinical impact of left ventricular hypertrophy and implications for regression. *Progress Cardiovascular Diseases.* 52(2):153–67.
3. Ascha, M., Renapurkar, R., &Tonelli, A. 2017. A Review of Imaging Modalities in Pulmonary Hypertension.*AnnThorac Med*. 12(2):61-73
4. Baumgartner, H., Hung, J., Bermejo, J., et al. 2009. Echocardiography Assessment of Valve Stenosis: EAE/ASE Recommendations for Clinical Practice*. European Journal of Echocardiography.*10, 1-25 (2009).
5. Boxt, L., &Abbara, S. 2016. *Cardiac Imaging: 4th Edition*. China: ELSEVIER
6. Brakohiapa,E., Botwe,B.,Sarkodie, B., Ofori, E., & Coleman, J. 2017. Radiographic Determination of Cardiomegaly using Cardiothoracic Ratio and Transverse Cardiac Diameter: Can One Size Fit All? Part One. *The Pan African Medical Journal.* 2017; 27:201
7. Camici, P., Olivotto, L., &Rimoldi, O. 2012.The Coronary Circulation and Blood Flow in Left Ventricular Hypertrophy. *Journal of Molecular and Cellular Cardiology*. 52 (4): 857-864
8. Chouham, N., Kumar, P., & Seth, A. 2008. *ECAB Clinical Update: Cardiology-Dilated Cardiomyopathy.* Amsterdam: Elsevier.
9. Cooper, R. & Schindler, S. 2006. *Business research methods.*Boston: McGraw-Hill.
10. D'Alto,M.,Dimopoulos,K., Budts, W., Diller, G., Salvo, G., et al. 2016. Multimodality Imaging in Congenital Heart Disease-Related Pulmonary Arterial Hypertension. *BMJ Journal*. 102:12 (2016).
11. Danzi, S., &Klein,I. 2014. Thyroid Disease and the Cardiovascular System. *Endocrinology and Metabolism Clinics.*43 (2): 517-528.
12. De Luca, G., Campochiaro, C., Dinarello, C., et al. 2018. Treatment of Dilated Cardiomyopath with Interleukin-1 Inhibition. *Ann Intern Med*. 2018; 169(11):819-82

13. Dong, N., Kampffmeyer, M., Liang, X., Wang, Z., Dai, W., & Xing, E. 2018. Uunsupervised Domain Adaptation for Automatic Estimation of Cardiothoracic Ratio. *Springer.*Volume11071.
14. Elhendy, A., Modesto, K.M., Mahoney, D.W. et al. 2003. Prediction of mortality in patients with left ventricular hypertrophy by clinical, exercise and echocardiographic data. *Journal of American College of Cardiology,* 41(1)129-135.
15. Elliot, C., Goldhaber, S., Visani, L., &DeRosa, M. 2000. Chest Radiographs in Acute Pulmonary Embolism: Results from the International Cooperative Pulmonary Embolism*. Chest Journal*. Volume 118 (1) 33-38.
16. Gollub, M., Panu, N., Delaney, H., Sohn, M.,Zheng, J., et al. 2012. Shall we Report Cardiomegaly at Routine Computed Tomography of the Chest? *JCAT.* 36:1
17. Greenwood, P., 2012. Cardiovascular magnetic resonance and single-photon emission computed tomography for diagnosis of coronary heart disease (CE-MARC): a prospective trial. *Lancet,*2012 Feb 4; 379(9814): 453–460
18. Guazzi, M., Vicenzi, M., Arena, R., &Guazzi, M.D. 2011. Pulmonary Hypertension in Heart Failure with Preserved Ejection Fraction. *AHA Journal's.* 124:164–174.
19. Healy, F., Hanna, B., &Zinman, R.2012.Pulmonary Complications of Congenital Heart Disease. *Paediatric Respiratory Review*. 13(1): 10-15
20. Hoeper, M., Bogaard, H., Condliffe, R., Frantz, R., Khanna, D., et al. 2013.Definitions and Diagnosis of Pulmonary Hypertension*. Journal of the American College of Cardiology,*62 (25). December 2013.
21. Hsich, M.2014. *Ejection Fraction***.** Available: from Cleveland Clinic: http://www.my.clevelandclinic.org/services/heart/disorders[March 17, 2015]
22. Isreal, G. 1992. *Determining Sample Size.* Florida: University of Florida. IFAS.
23. Imazi, M.,& Adler, Y. 2013. Management of Pericardial Effusion. *European Heart Journal.* 34: (16), 1186–1197,
24. Japp, A., Gulati, A., Cook, S., Cowie, M & Prasad, S. 2016. The Diagnosis and Evaluation of Dilated Cardiomyopathy.*Journal of the American College of Cardiology:* 67 (3).
25. Kealy, K. &Mcallister, H. 2010. *Diagnostic Radiology & Ultrasonography of the Dog and Cat.* 5th ed. Oxford: Elsevier.

26. King, M., Kingery, J., & Casey, B. 2012. Diagnosis and Evaluation of Heart Failure. *AmFam Physician*. 85(12):1161-1168.
27. Klein, I., &Danzi, S. 2016. Thyroid Disease and the Heart. *Current problems in Cardiology.* 41 (2): 65-92.
28. Lancellotti, P., Price, S., Edvardsen, T., Cosyns, B., Neskovic, A., et al. 2014.The use of Echocardiography in Acute Cardiovascular Care: Recommendations of the European Association of Cardiovascular Imaging and the Acute Cardiovascular Care Association.*European Heart Journal.*16 (2): 119-146.
29. Lavie, J., Milani, V., Patel, D., Artham, M. & Ventura, O. 2009. Disparate Effects of Obesity and Left Ventricular Geometry on Mortality in 8088 Elderly Patients with Preserved Systolic Function. *Postgraduate Medicine,* 21(3):119–25.
30. Levy Mwanawasa General Hospital. 2015. *Radiology Department* Register*.* Lusaka: Levy Mwanawasa General Hospital.
31. Levy Mwanawasa General Hospital. 2016. *Hospital Information's System Report for 2015.* Lusaka: Levy Mwanawasa General Hospital.
32. Luscher, T. 2016. Cardiomyopathies: Definition, Diagnosis, Causes, and Genetics. *European Heart Journal*, 37, 1779-1782.
33. Mapulanga, M. 2010. The socio-economic impact of stroke on households in Livingstone district, Zambia. *UNZA-SOM*, 45-51.
34. Marian, A., &Braunwald, E. 2017.Hypertrophic Cardiomyopathy. *American Heart Association Journal,* 121:749-770.
35. Mathew, T., Williams, L., Navaratam, G., et al. 2017. Diagnosis and Assessment of Dilated Cardiomyopathy: A Guideline Protocol from the British Society of Echocardiography. *Echo Research and Practice*, G1-G13. (DOI:10.1530/ERP-16-0037)
36. Maclver, D. 2012.The Relative Impact of Circumferential and Longitudinal Shortening on Left Ventricular Ejection Fraction and Stroke Volume. *Experimental & Clinical Cardiology*. 17(1): 5–11
37. Mckee, J., & Ferrier, K. 2017.Is Cardiomegaly on Chest Radiograph Representative of True Cardiomegaly: A Cross-Sectional Observational Study Comparing Cardiac Size on Chest Radiograph to that on Echocardiography. *The New Zealand Medical Journal*, 130:1464.

38. Meijs, M. 2007. Rationale and design of the smart heart study: A prediction model for left ventricular hypertrophy in hypertension. *Netherlands Heart Journal,* 15(18), 295-8.
39. Mensah, Y., Mensah, K., Asiamah, S. Gbadamosi, H., Idun, E., Brakopjiapa, W., &Oddoye, A. 2015. Establishing the Cardiothoracic Ratio Using Chest Radiographs in Indigenous GhaniansPopulation.A Simple Tool for Cardiomegaly Screening. *GhanaMedical Journal.* 49 (3) 159-164.
40. Misra, R., Planner, A. &Uthappa, M. 2007. *A-Z of Chest Radiology.* New York: Cambridge University Press.
41. Monfared, A., Farajollah, S., Sabour, F., Farzanegan, R., &Taghadisi, S. 2015. Comparison of Radiological Findings of CXR with Echocardiography in Determining the Heart Size. *Red Crescent Medical Journal*.17 (1) ie18242.
42. Morales, M., Prediletto, R., Rossi, G., Catapano, G., Lombardi, M., &Rovai, D. 2012. Routine Chest X-ray: Still Valuable for the Assessment of Left Ventricular Size and Function in the Era of Super Machines? *Journal of Clinical Imaging Science.*2:25.
43. Muranda, Z. 2004. *Dissertation Writing: Concepts and Practice.* Harare: UZ Publications.
44. Nashimura, A. 2014. American College of Cardiology: Guidelines for the Management of Patients with Valvular Heart Disease. *American College of Cardiology Journal*, 13-17.
45. Nyland, G., Matton, S., Herrgesell, J., & Wisner R. 2002. *Physical Principles, Instrumentation, and Safety of Diagnostic Ultrasound.* St. Louis: Elsevier.
46. Otto, C., & Prendergast, B. 2014. Aortic-Valve Stenosis-From Patients at Risk to Severe Valve Obstruction. *The English Journal of Medicine*, 371:744-56.
47. Parsai, C., O'Hanlon, R., and Prasad, K. 2012. Diagnostic and Prognostic Value of Cardiovascular Magnetic Resonance in Non-Ischaemic Cardiomyopathies*. J CardiovascMagnReson. 14:54.*
48. Patel, R. 2010. *Lecture Notes Radiology.* 3rd ed. West Sussex: John Wiley & Sons Ltd.

49. Peterson, D. 2014. The Ventricular Complex in Left Ventricular Hypertrophy as Obtained by Unipolar Precordial and Limb Leads. *American Heart Journal, 37*, 161-186.
50. Qiu, Y., Gigliotti, J., Wallace, M., Griggio, F., Demore, C., et al. 2015. Piezoelectric Micromachined Ultrasound Transducer (PMUT) Arrays for Integrated Sensing, Actuation and Imaging. *Sensors*. 5 *(4), 8020-8041.*
51. Rosenkranz, S., Gibbs, J., Wachter, R., Marco, T., &Vonk, A.2015. Left Ventricular Heart Failure and Pulmonary Hypertension. European Heart Journal. 37 (12): 942-954.
52. Ryszard, P. 2012. *Cardiomegaly in tropical Africa*. Nigeria: Madonna University.
53. Sakamoto, A., Yahagi, K., Romero, M., and Virmani, R.Hypertrophic Cardiomyopathy. *Springer,* 23 to 29, 2019.
54. Sanders, R. &Terracciano, B. 2016. *Clinical Sonography. A Practical Guide*. 5th ed. Philadelphia: Wolters Kluwer.
55. Saura, D., Dulghera, R., Caballero, L., Bernard, A., et al. 2017. Two- Dimensional Transthoracic Echocardiographic Normal Reference Ranges for Proximal Aorta Dimensions: Results from the EACVI NORRE Study. *European Heart Journal-Cardiovascular Imaging*. 18, 167-179.
56. Schild, D.,Ricciardi, S., Hellige, J., Vogel, R and Arenja, N. 2019. *Current Pathophysiological and Genetic Aspects of Dilated Cardiomyopathy*. Available: https://www.intechopen.com/online-first/current-pathophysiological-and-genetic-aspects-of-dilated-cardiomyopathy
57. Scoot, F.,Walker, J., & Ramesh, P. 2018. G252 (P) How Relevant is an Incidental Finding of Abnormal Cardiac Silhouette on Chest X Ray? *Archives of Disease in Childhood*. (suppl 1), A103-A104,2018.
58. Screaton N. 2010. The Cardiothoracic Ratio--an Inaccurate and Outdated Measurement: *New Data from CT. European Radiology***.** 20(7):1597–8.
59. Shammas, R., Khan, A., Nekkanti, R., &Movahed, A. 2017.Diastolic Heart Failure and Left Ventricular Diastolic Dysfunction: What we know, and what we don't know! *International Journal of Cardiology*. 115 (3): 284-29.
60. Sherif, N., Otto, S., Christopher, A., Benjamin, B., Hisham, D., et al. 2016.Recommendations for the Evaluation of Left Ventricular Diastolic Function

by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *European Heart Journal.* 17 (12) 1321–1360.

61. Santos, M., & Shah, A. 2014.Alterations in Cardiac Structure and Function in Hypertension. *Springer*. May 2014:16:428
62. Spiewak, M., Malek, A., Biernacka, K., Kowalski, M., Michalowska, I., Hoffman, P., et al. 2014. Cardiothoracic Ratio May be Misleading in the Assessment of Right- and Left-Ventricular Size in Patients with Repaired Tetralogy of Fallot. *Clinical Radiology*. 69(7):1–8.
63. Tam, C. 2006. Application of Echocardiography in Clinical Practice. *Medical Bulletin.* 12 (3).
64. Tavora, F., Zhang, Y., Zhang, M., Ripple, M. Fowler, D., & Burker, A. 2012. Cardiomegaly is a Common Arrhythmogenic Substrate in Adult Sudden Cardiac Deaths and is Associated with Obesity. *Pathology*.44 (3) 187-91.
65. Thomas, R.& Lee, Y. 2013. Causes and Management of Common Benign Pleural Effusions. *Thoracic Surgery Clinics*. 23 (1) 25-45.
66. Tomaszewski, R. 2012. Cardiomegaly in Tropical Africa**.** *National Centre for Biotechnology Information*. 63 (1) 56-8
67. Top, L., Delgado, V., Marsan, N., &J eroen, J. 2016. Myocardial Strain to Detect Subtle Left Ventricular Systolic Dysfunction. *European Journal of Heart Failure*. 19 (13):307-313.
68. Tsang, T. 2000. Diagnostic Value of Echocardiography in Cardiac Temponade. *Herz, 25*(8), 734-740.
69. Tudar, R., Archer, S., Dorfmuller, P., Erzurum, S., Guignabert, C., et al. 2013. Relevant Issues in the Pathology and Pathobiology of Pulmonary Hypertension.*Journal of the American College of Cardiology*. 62 (25). December 2013.
70. Varma, K., Neema, P. 2014. Hypertrophic Cardiomyopathy: Part 1-Introduction, Pathology & Pathophysiology*. Annals of Cardiac Anaesthesia*. 17(2):118-24.
71. Wang, X., Peng, Y., Lu, L., Lu, Z., Bagheri, M., Summers, R. 2017.ChestX-ray8: Hospital-Scale Chest X-Ray Database and Benchmarks on Weakly-Supervised

Classification and Localization of Common Thorax Diseases.*The IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*: 2097-2106.

72. Watkins, A. 2012.*Thesis/ Dissertation/ Research Reports: A practical guide for Students to the Preparation of Written Presentations of Academic Research*. Cape Town: Lavender Moon Publishing.
73. Willis, J. 2004. *Data Analysis and Presentation Skills: An Introduction for the Life and Medical Sciences.* West Sussex: John Wiley and Sons Ltd.
74. World Heart Federation. 2017. *Risk Factors*. Available: https://www.world-heart-federation.org/resources/risk-factors/
75. World Health Organization. 2014. *Non Communicable Diseases Country Profile*. Geneva: World Health Organization.
76. World Health Organization. 2016*. Cardiovascular Diseases; New Initiative Launched to Tackle Cardiovascular Diseases, the World's Number One Killer*. Geneva: World Health Organization.
77. Zoghbi, W. 2003. Recommendations for the evaluation of severity of native valvular regurgitation with 2D and Doppler echocardiography. *Journal for the American society of echocardiography,* 16, 777-802.

LISTOF APPENDICES

<u>Appendix A</u>: Form for capturing patient's data-CXR report

Please complete a form for each patient whose data is being captured in this study.

Study No:	AGE:	SEX:	DATE:	
Blood Pressure:				
Cardiomegaly seen on CXR:	Yes		No	
If cardiomegaly is seen, indicate the CTR:				
Any lung disease seen on CXR:	Seen		Not	
If seen, Kindly specify:				
CONCLUSION:				

REPORTED BY:

NAME: ……..

SIGNATURE: ……

All forms will be collected by: Nchimunya Gwaba, contact no: +260965913947 and the Research assistant who will be a registry clerk at the research site

<u>Appendix B</u>: Form for capturing patient's data- ECHO report

Please complete a form for each patient whose data is being captured in this study.

Study No:	AGE:	SEX:	DATE:
Blood Pressure:			
Cardiomegaly seen on CXR:	Yes	No	
ECHOCARDIOGRAM REPORT:			
AORTIC VALVE:			
AORTIC ROOT:		RIGHT VENTRICULAR OUTFLOW TRACK:	
LEFT ATRIUM:			
LEFT VENTRICLE:			
FRACTIONAL SHORTENING:		EJECTION FRACTION:	
MITRAL VALVE:			
INTER VENTRICULAR SEPTUM:			
POSTERIOR WALL (LV):			
PERICARDIAL EFFUSION:			
VEGETATION:		THROMBUS:	
OTHER FINDINGS:		DOPPLER:	
CONCLUSION:			

REPORTED BY:

NAME: ……..…….

SIGNATURE: ……..……

All forms will be collected by: Nchimunya Gwaba, contact no: +260965913947

Appendix C: Participant Information Leaflet - for Research Assistants of the study.

Date:

Participant Information Leaflet by Nchimunya Gwaba; Cell no: +260 965913947

As Diagnostic Radiographer it is part of our goal to contribute and continuously offer quality diagnostic services to our clients, as well as continuously strive into research ventures that will bring new knowledge, enabling us to improve our patient management and care.

Please take some time to read the information presented here which will explain the details of this project. Please ask the principal investigator about any part of the project that you do not fully understand. It is very important that you are fully satisfied as to what the research entails. Your participation is entirely voluntary and you are free to withdraw at any stage if you say so, this will not affect you negatively in any way whatsoever.

What is the Research Study all about?

This research study aims to determine the association between cardiomegaly identified on CXR and ECHO results of the same patient at LMGH in Lusaka, Zambia.

Files of participants who have undergone an echocardiography examination after cardiomegaly has been identified on a CXR, using the standard imaging procedures for these examinations, will be analysed-in order to determine the common conditions found in cardiomegaly patients.

Being a retrospective study, particular attention will be paid to issues of confidentiality by ensuring that all information that come into the possession of the researcher and his assistants during the study is not shared with any unauthorized person.

Why have you been invited to participate?

The researcher's main interests are patients with an enlarged heart on CXR. The study will be conducted retrospectively and thus patients will not be required to sign this consent form. However, the research assistant, the head of the radiology department, and research supervisor will be required to read this form as they will play a role in this research and will thus be requested to keep patient details confidential. Refer to HWS-REC 4.1 form.

What will your responsibility be?

The study will be conducted retrospectively and thus patients will not be required to sign this consent form. However, the research assistants will be required to retrieve patient's files that have been identified with an enlarged heart on CXR and have undergone ECHO. The research assistant, together with the research supervisor and head of the radiology department will be required to keep patient confidentiality by not discussing patient's details with those that are not directly related to this study.

Will you benefit from taking part in this research?

Are there any benefits (financial/nonfinancial) to your taking part in this study?

There are no financial benefits, to those whose files will be used for this study, related to this study. Using the patient's participant's file in this study will also not lead patients to spend any extra money as is related to this research.

This study will help us determine the association between cardiomegaly identified on CXR and ECHO findings of the same patient at LMGH in Lusaka, Zambia. The research may thus benefit patients and their families or community in future as the research may enhance more knowledge on the need for more consorted efforts in combating cardiomegaly in particular and cardiovascular diseases in general. In addition, this research may also benefit consulting cardiologist, physicians and clinical educators in the management of cardiovascular diseases in adults above the age of 18 years with cardiomegaly that is related to IHD and increased rate of morbidity and mortality.

It should also be brought to your attention that the researcher will not benefit financially from the study as well, although the researcher will continue drawing his normal salary as a radiographer.

Are there any risks involved in your taking part in this research?

There will be no known risks attributed to this research study as the research will be conducted retrospectively.

Who will have access to your medical records?

All the data being collected in this research will be coded, and the patients name will not be used to ensure confidentiality. The data will be stored in the department safe, and only

the principal investigator, research supervisor and the head of the radiology department will have access to this information.

Thank you.

Appendix D: Permission to Carry out research

All Communications should be addressed to:
The Senior Medical Superintendent
Tel: +260 211 285451
Fax: +260 211 285462

In reply please quote

No.:.....

REPUBLIC OF ZAMBIA

MINISTRY OF HEALTH

LEVY MWANAWASA UNIVERSITY
TEACHING HOSPITAL
P.O. BOX 310084
LUSAKA

10th August, 2017

The Chairperson
Ethics Committee
Cape Peninsula University of Technology
Capetown
South Africa

Dear Sir/ Madam,

RE: PERMISSION TO CARRY OUT RESEARCH- NCHIMUNYA GWABA

Reference is made to the above captioned matter.

I'm here by writing to inform you that the institution has no objection for the above mentioned student, who is pursuing a Master of Science in Radiography at your institution to carry out his research titled "**Echocardiograph in Patients with Chest X-ray Diagnosis or Cardiomegaly at an Academic Hospital in Zambia".**

Your consideration will be highly appreciated.

Yours faithfully,

Dr. L. Chikoya
Senior Medical Superintendent

Appendix E: Ethics Certificate

Cape Peninsula University of Technology

HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HW-REC)
Registration Number NHREC: REC- 230408-014

P.O. Box 1906 • Bellville 7535 South Africa
Symphony Road Bellville 7535
Tel: +27 21 959 6917
Email: sethn@cput.ac.za

2 August 2017
REC Approval Reference No:
CPUT/HW-REC 2017/H22

Dear Nchimunya Gwaba

Re: APPLICATION TO THE HW-REC FOR ETHICS CLEARANCE

Approval was granted by the Health and Wellness Sciences-REC on 15 June 2017 to Mr Gwaba for ethical clearance. This approval is for research activities related to student research in the Department of Medical Imaging & Therapeutic at this Institution.

TITLE: Echonocardiagraphy and chest x-ray diagnosis of cardiomegaly at an academic hospital in Zambia

Supervisor: Ms F Isaacs

Comment:

Approval will not extend beyond 3 August 2018. An extension should be applied for 6 weeks before this expiry date should data collection and use/analysis of data, information and/or samples for this study continue beyond this date.

The investigator(s) should understand the ethical conditions under which they are authorized to carry out this study and they should be compliant to these conditions. It is required that the investigator(s) complete an **annual progress report** that should be submitted to the HWS-REC in December of that particular year, for the HWS-REC to be kept informed of the progress and of any problems you may have encountered.

Kind Regards

Mr. Navindhra Naidoo
Chairperson – Research Ethics Committee
Faculty of Health and Wellness Sciences