Eunice Tiwaloluwa
OLAWALE

FREQUENCY OF MYOCARDIAL BRIDGE IN THE POPULATION OF THE TURKISH REPUBLIC OF NORTHERN CYPRUS

Nicosia

September, 2022

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MSc. THESIS

Eunice Tiwaloluwa OLAWALE

Supervisor

Prof. Dr. Mehtap Tiryakioglu

Nicosia

September, 2022

Approval

We certify that we have read the thesis submitted by Eunice Tiwaloluwa OLAWALE titled **"Frequency of Myocardial in the population of the Turkish Republic of Northern Cyprus (TRNC)"** and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Educational Sciences.

Examining Committee	Name-Surname	Signature
Head of the Committee:	Prof. Dr. Sezgin Ilgi	.....
Committee Member*:	Asst. Prof. Dr. Musa Muhtaroglu	.....
Supervisor:	Prof. Dr. Mehtap Tiryakioglu	.....

Approved by the Head of the Department

03./02./2023

Prof. Dr. Sezgin Ilgi

Head of Department

Approved by the Institute of Graduate Studies

...../...../20...

Prof. Dr. Kemal Hüsnü Can Başer

Head of the Institute

Declaration

I hereby declare that all information, documents, analysis and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of Institute of Graduate Studies, Near East University. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

Eunice Tiwaloluwa OLAWALE

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Eunice Tiwaloluwa OLAWALE

Abstract

Frequency of Myocardial Bridge in the Population of the

Turkish Republic of Northern Cyprus (TRNC)

OLAWALE Eunice Tiwaloluwa

MA, Department of Anatomy

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Introduction: Myocardial Bridge is a condition that can be referred to as intramyocardial systolic of a segment of an epicardial coronary artery (Mookadam et al 2009). According to (Chen et al., 2009), myocardial bridge is a condition characterized by the surrounding myocardium tunneling a sizable percentage of the epicardial coronary artery. Congenital cardiac abnormality known as myocardial bridge was first identified in an autopsy carried out by Reyman in 1737 and was first reported using angiography by Porstmann and Iwig in 1960. (M.Sivananthan, 2018) Myocardial bridge was defined as the existence of an intramural course of a coronary artery by Ceaus et al. (2013).

Materials and Methods: During the period between 2016 and 2022, a total number of 740 radiographs of patients were collected from the Radiology department of Kyrenia University Hospital in the Turkish Republic of Northern Cyprus.

The data collected were evaluated statistically using One-way Anova and Statistics

Package for Social Sciences (SPSS) version 24.

Results: Myocardial Bridge was found in 520 patients (70.3%) of the 740 radiographs while 220 patients were found to not have myocardial bridge which accounts for 29.7%.

Conclusion: After the analysis, it has been discovered that the frequency of myocardial bridge is 70.3% in our study sample and we discovered that it is more prevalent in males than in females and it mostly occurs in the left anterior descending artery (LAD

Keywords: myocardial bridge, coronary arteries, computed tomography coronary

angiography (CTCA).

Öz

Popülasyonunda Miyokardiyal Köprü Sıklığı

Kuzey Kıbrıs Türk Cumhuriyeti (KKTC)

OLAWALE Eunice Tiwaloluwa

Yüksek Lisans, Anatomi Bölümü

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Giriş: Miyokardiyal köprü, bir epikardiyal koroner arter segmentinin intramiyokardiyal sistolik olarak adlandırılabilecek bir durumdur (Mookadam ve ark. 2009). Chen ve ark., (2009)'a göre, miyokard köprüsü, çevreleyen miyokardın epikardiyal koroner arterin büyük bir yüzdesini tünellemesi ile karakterize edilen bir durumdur. Miyokard köprüsü olarak bilinen konjenital kalp anomalisi ilk olarak 1737 yılında Reyman tarafından yapılan otopside tanımlanmış ve ilk kez 1960 yılında Porstmann ve Iwig tarafından anjiyografi kullanılarak rapor edilmiştir. (M.Sivananthan, 2018) Miyokard köprüsü, intramural seyrin varlığı olarak tanımlandı Koroner arterin Ceaus ve ark. (2013).

Gereç ve Yöntem: 2016-2022 yılları arasında Kuzey Kıbrıs Türk Cumhuriyeti'ndeki Girne Üniversite Hastanesi Radyoloji bölümünden toplam 740 hasta radyografisi toplandı. Toplanan veriler, One-way Anova ve Sosyal Bilimler için İstatistik Paketi (SPSS) 24 sürümü kullanılarak istatistiksel olarak değerlendirildi.

Bulgular: 740 radyografinin 520'sinde (%70.3) miyokard köprüsü saptanırken, 220 hastada %29.7'lik miyokard köprüsünün olmadığı saptandı.

Sonuç: Analiz sonrası çalışma örneklemimizde miyokard köprüsü sıklığının %70,3 olduğu ve erkeklerde kadınlara göre daha sık görüldüğünü ve daha çok sol ön inen arterde (LAD) meydana geldiğini keşfettik.

***Anahtar Kelimeler**:* miyokard köprüsü, koroner arterler, bilgisayarlı tomografi koroner anjiyografi (CTCA)

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Abbreviations

TRNC: Turkish Republic of North Cyprus

MNE: Ministry of National Education

SPSS: Statistical Package for Social Science

CTCA: Computed Tomography Coronary Angiography

PACS: Picture Archiving and Communication System

CHAPTER I

Introduction

Myocardial bridge is a condition that can be referred to as intramyocardial systolic of a segment of an epicardial coronary artery (Mookadam et al., 2009). According to (Chen et al., 2009), myocardial bridge is a condition characterized by the surrounding myocardium tunneling a sizable percentage of the epicardial coronary artery. Congenital cardiac abnormality known as myocardial bridge was first identified in an autopsy carried out by Reyman in 1737 and was first reported using angiography by Porstmann and Iwig in 1960 (M. Sivananthan, 2018). Myocardial bridge was defined as the existence of an intramural course of a coronary artery by Ceaus et al. (2013). This condition is usually brought on by an abnormality in the resorption of the muscle around epicardial arteries during embryological development. Myocardial bridge ranks as the second most prevalent kind of coronary artery dysfunction, and it occurs when there is a dive in the epicardial segments of the coronary arteries (M. Sivananthan, 2018). For the most part, myocardial bridge does not cause any harm (M. Sivananthan, 2018). Patients with a myocardial bridge have it right from birth, and most never know they have a condition (M. Sivananthan, 2018). However, it may cause myocardial ischemia, which may lead to angina symptoms such as chest pain and shortness of breath, acute coronary syndrome, cardiac arrhythmias and rarely sudden cardiac death (Ghulam et al., 2020). Myocardial ischemia occurs when the heart muscle is deprived of sufficient oxygen-rich blood, when the heart contracts during a heartbeat, the heart muscle bridge can tighten down on an artery and reduce blood flow. Fortunately, the majority of blood flow through the heart occurs during the rest part of the heartbeat, rather than the contraction phase (Alan H. Friedman, 2010).

Exercise induced ventricular tachycardia has been said to be uncommon (Field et al., 1991). Nonetheless, the tightness of the artery's bridge can reduce blood flow to the point where myocardial ischemia develops, particularly during exercise or when the heart is pounding rapidly (Alan H. Friedman, 2010). Recent studies have highlighted that exercise and tachycardia can provoke symptoms associated with myocardial bridging (Arjun et al 2020). In patients with ≥ 70% systolic compression, it is linked to angina pectoris and myocardial infarction. Also, the bridging segment can contribute to the production of more atherosclerotic plaque (Mookadam et al 2009).

Myocardial bridge is mostly found in the central part of the left anterior descending (LAD) coronary artery, where the bridges have a wide range of anatomical properties which include; length, thickness and location (Ishikawa et al 2009)
Even if there are no clear-cut in-depth criteria for the classification of myocardial bridging displayed on CTA, it can be characterized as superficial or deep depending on the thickness of the overlying muscle layer (1 mm or > 1 mm) (Ferreira Jr, et al., 1991). In addition, depending on the amount of the myocardium's encasement of the artery, superficial myocardial bridging can be characterized as complete or incomplete (Zeina et al 2007). In complete myocardial bridging, myocardium completely covers the artery while in incomplete myocardial bridging a thin layer of connective tissue and fatty tissue covers the artery (Kim et al 2011).
The main coronary arteries are: the right coronary artery (RCA) left anterior descending artery (LAD) and the circumflex artery (CX). In previous studies, the LAD is frequently observed, and has been correctly interpreted as evidence of myocardial bridging (Bruschke, 2009). Since the last decade, studies have shown that myocardial bridge can be detected by computed tomography coronary angiography (CTCA), which has rekindled the interest in this anomaly (Kim SY, 2006). Hazirolan T, (2007) predicted that increasing numbers of patients with myocardial bridging will be detected through CTCA, which may greatly enhance future understanding of the pathological and clinical consequences of myocardial bridge. This motivated our decision to elucidate the frequency and locations of myocardial bridge in the population of the Turkish Republic of Northern Cyprus (TRNC).

1.1 Statement of the Problem

Myocardial bridge has been shown to contribute to sudden cases of myocardial infarction, arrhythmias, etc., which can be fatal if not properly managed (Ceaesu et al., 2013). Awareness of a non-invasive imaging technique with high predictability in diagnosing myocardial bridge will be an important tool to mitigate the risks associated with myocardial bridge, and improve various therapeutic measures designed to mitigate the outcome of this clinical condition. Consequently, this study is geared toward establishing the frequency and locations of myocardial bridge in the population of the Turkish Republic of Northern Cyprus (TRNC)**.**

1.2 Purpose of the Study

This present study aims to establish the frequency and locations of myocardial bridge in the population of the Turkish Republic of Northern Cyprus (TRNC).

1.3 Objectives of the Study

1. To evaluate the frequency of myocardial bridge in the population of TRNC
2. To evaluate the most frequent myocardial bridge of the heart in the population of TRNC
3. To evaluate the less frequent myocardial bridge of the heart in the population of TRNC
4. To evaluate the frequency of myocardial bridge in male and female in the population of TRNC.

1.4 Research Questions/Hypotheses

1. What is the frequency of myocardial bridge in the population of TRNC?
2. Which is the most frequent myocardial bridge of the heart in the population of TRNC?
3. Which is the less frequent myocardial bridge of the heart in the population of TRNC?
4. Does myocardial bridge occur mostly in male than in female in the population of TRNC?

1.5 Significance of the Study

In previous studies, a myocardial bridge could only be seen during autopsy as recognized by Reyman (Ripa, C et. al., 2007). This study will seek to establish the frequency of myocardial bridge in the population of TRNC, using sample data from Kyrenia University Hospital. A diagnostic method used is CTA (a non-invasive method with high sensitivity that allows the cardiac architecture, particularly the coronary arteries to be seen accurately), in evaluating myocardial bridge. This will create an established method of analyzing and diagnosing this congenital abnormality thereby providing opportunities to address and mitigate the outcomes associated with myocardial bridge in the population.

1.6 Limitations

- Limited access to patient information.

1.7 Definition of Terms

MYOCARDIAL BRIDGE- This is a condition in which one or more of the coronary arteries go through the heart muscle instead of lying on its surface.

ANTERIOR DESCENDING ARTERY- The left anterior descending artery branches off the left coronary artery and supplies blood to the front of the left side of the heart.

CORONARY ARTERY DISEASE- This is a narrowing of the coronary arteries usually caused by the buildup of fatty material called plaque.

ACUTE MYOCARDIAL INFARCTION- This is a clinical condition characterized by death of cardiac muscles due to lack of blood supply.

COMPUTED TOMOGRAPHY- This phrase describes a technique for computerized x-ray imaging in which a patient is subjected to a small beam of x-rays that is quickly rotated around the body, producing signals that are then analyzed by the machine's computer to produce cross-sectional images.

COMPUTED TOMOGRAPHY CORONARY ANGIOGRAPHY- an imaging test that looks at the arteries that supply blood to the heart.

CHAPTER II

Literature review

The primary coronary arteries are called epicardial coronary arteries since they lie on the surface of the heart. However, some of the coronary arteries may dip into the heart muscle, and the part of myocardium overlying this coronary artery is called a myocardial bridge (Möhlenkamp et al., 2002). Some bridging of the myocardium is fairly common and it is reported that a quarter of adults have a level of bridging, and majority of bridges affect about 70% of the left anterior descending (LAD) (Möhlenkamp et al., 2002). Most bridges are quite mild and very thin. Thick bridges which are exacerbated by myocardial hypertrophy can potentially cause symptoms (Arjun et al., 2020).

Even if there are no clear-cut in-depth criteria for the classification of myocardial bridge displayed on CTA, it can be characterized as superficial or deep depending on the thickness of the overlying muscle layer (1 mm or > 1 mm). In addition, depending on the amount of the myocardium's encasement of the artery, superficial myocardial bridging can be characterized as complete or incomplete. (Zeina et al 2007) In complete myocardial bridging, the artery is completely covered with myocardium while in incomplete myocardial bridging; the artery is covered by a thin layer of connective tissue and fatty tissue (Kim et al 2011).

The main coronary arteries are: the right coronary artery (RCA), the left anterior descending artery (LAD) and the left circumflex artery (LCX). According to the classification of the American Heart Association, these coronary arteries are subdivided into 15 segments: RCA, segments 1–4, left main coronary artery (LM, segment 5, LAD, segments 6–10, LCX, segments 11–15 (Austen et al., 1975).

2.1 Embryology

Angioblasts, which are created from sinus venosus sprouts and dispersed over the surface of the heart via cell migration, and the epicardium itself, are the two origins from which coronary arteries emerge. The underlying myocardium produces an epithelial-to-mesenchymal transition in a few of the epicardial cells (Langman, 2012, p. 201). The endothelial and smooth muscle cells of the coronary arteries are then produced from the newly formed mesenchymal cells. Along the proximal parts of these arteries, smooth muscle cells are also contributed by neural crest cells. Arterial endothelial cells from the arteries develop into the aorta to form the

connection between the coronary arteries and the aorta. The coronary arteries "invade" the aorta using this method (Langman, 2012, p. 201).

2.1.1 *Arteries*

The artery is a major part of the body transport system as they are responsible for transporting oxygenated blood from to the tissues in the body from the heart. Arteries are most often under stress and they have a lot of less smooth muscle and elastic tissue elastic tissue to deal with tension (Tucker et al., 2017). An artery is further divided into smaller arteries with more smooth muscle and elastic tissue when it reaches a particular organ (Tucker et al., 2017). The blood vessels in the body consist of 3 layers, namely;

- Tunica intima
- Tunica media and
- Tunica adventitia

2.1.2 *Tunica intima*

This is known as the internal layer of the vessel. It is an endothelial layer that is elongated in the direction of blood flow, it functions as a semi-permeable membrane, through which chemical signals and nutrients can get to the cells in the vessel wall from the bloodstream (Fortier et al., 2014). The intima also plays an important function in maintaining the vessel's active response, which allows pressure-regulatory chemicals to reach the media. Additionally, the intima releases NO (nitric oxide) which helps in relaxing smooth muscle cells in the media to assist modulate vascular tone (Fortier et al., 2014).

2.1.3 *Tunica Media*

Smooth muscle cells (SMC) are found in an extracellular plexus of elastin and collagen (mostly types 1 and 3), as well as a fluid ground substance including proteoglycans, to create the media (Fortier et al. 2014). The media is classified into elastic and muscular arteries based on the internal arrangement of its smooth muscle cell (Fortier et al. 2014). The elastic arteries are the large diameter vessels close to the heart; they include the aorta, the main pulmonary artery, common carotid and common iliac arteries.

The so-called lamellar unit, a sandwich-like 'sublayer' of smooth muscle cells and thin elastic laminae, is their most distinguishing histological feature. Elastic arteries have radially directed collagen that connects concentric ring-like structures (Fortier et al. 2014).

Muscular arteries include arteries like the radial artery, femoral artery and brachial artery for example. Muscular arteries contain more smooth muscle cells in the tunica media layer than the elastic arteries (Tucker, et al. 2017).

2.1.4 *Tunica Adventitia*

This is known as the outermost layer of the vessel wall. It serves as a dynamic compartment for cell trafficking into and out of the artery wall, contributes in vessel wall growth and repair, and mediates communication between vascular endothelial cells and SMCs and their surrounding tissue (Majesky, et al. 2011). The adventitia is also where micro vessels that penetrate and nourish the media and intima are formed and retracted. The adventitia contains lymphatic arteries and autonomic nerves, and it regulates medial smooth muscle tone and controls inward (negative) and outward (positive) wall remodeling responses to control lumen size (Majesky, et al. 2011). It consists of a dense network of type I collagen fibers with scattered fibroblasts, elastin and nerves. The presence of nerves in the adventitia allows innervation of smooth muscle in the outer media, via the diffusion of neurotransmitters. As for the fibroblasts, they are responsible for collagen production, particularly type I, and thus regulate the connective tissue. The fibers progressively straighten at greater pressures, corroborating the concept that the adventitia acts as a protective coating, preventing vessel rupture owing to an abrupt increase in pressure (Fortier et al., 2014).

The primary coronary arteries are called epicardial coronary arteries since they lie on the surface of the heart. However, some of the coronary arteries may dip into the heart muscle, and the part of myocardium overlying this coronary artery is called a myocardial bridge (Möhlenkamp et al., 2002). Some bridging of the myocardium is fairly common and it reported that a quarter of adults have a level of bridging, majority of bridges affect about 70% of the LAD (Möhlenkamp et al., 2002). Most bridges are quite mild and very thin. Thick bridges are exacerbated by myocardial hypertrophy can potentially cause symptoms.

2.2 Pathophysiology of Myocardial Bridging

The majority of coronary perfusion occurs during diastole, when the bridges compress (Heward et al., 2022). It's not clear why bridges should constitute an issue, and in many circumstances, they do not. The reason why bridges become troublesome is not always evident, but there might be various elements at play (Ripa C, et. al., 2007). Coronary constriction can linger throughout diastole in more severe bridges, and as patients age and acquire smaller channel CAD, a progressive decline in coronary perfusion time during diastole might begin to cause symptoms. Tachycardia can similarly cause symptoms by shortening the duration of the diastole (Ripa C, et. al., 2007). It is uncommon to find CAD inside the bridge, it frequently occurs immediately proximal to the bridge, where blood flow is disrupted hence; symptoms develop over time (Jorge et al. 2005).

The condition called a myocardial bridge has been defined to occur when the coronary artery that is meant to sit on the surface of the heart, tunnels into the heart muscle and then comes out. Theoretically we may think that the contraction of the heart will cause a significant squeeze on the intra-myocardial portion of the artery (Heward et al., 2022). However, we know that most of the filling of the heart vessel occurs when the heart is relaxing. Myocardial bridge doesn’t seem to affect much people because most of the artery filling is during relaxation of the heart (Heward et al., 2022). Studies have shown that the pressure along the coronary artery differs in areas of the bridge, proximal to the bridge or distal to the bridge. (Gej et al., 1995) concluded that the pressure proximal to the myocardial bridge was greater than the aortic pressure, and disruption of blood flow and wall share stress (WSS) proximal to the myocardial bridge were the primary causes of atherosclerosis in the proximal segment. This conclusion was reached after studying a patient without myocardial bridge, they revealed that the pressure in the LAD segment at the myocardial bridge was higher (160/26 mmHg) than in a normal proximal section (126/68 mmHg). The pressure was 68/30 mmHg distal to the myocardial bridge (Gej et al., 1995).

The patient's age, heart rate, left ventricular (LV) hypertrophy, and the existence of coronary atherosclerosis are clinical and pathophysiological variables that may reveal or worsen myocardial bridge. In this aspect, age, LV hypertrophy, and coronary atherosclerosis may aggravate not only the supply-demand imbalance imposed by the bridge, but also impair micro vascular reserve by compressing the microvasculature (Corban et al., 2014)

Additional pathophysiological alterations can cause myocardial ischemia symptoms in previously asymptomatic patients. The ischemia is as a result of endothelial damage, vasospasm, and atherosclerotic processes emerging in the proximal section of the bridge segment (Hostiuc et al., 2011). Endothelial damage produced by systolic constriction at the myocardial bridging segment might lead to platelet aggregation, coronary vasospasm, and finally acute coronary syndrome (Hostiuc et al., 2011).

Other pathophysiological conclusions that can be drawn from the study of (Corban et al., 2014) include:

- The development of left ventricular hypertrophy can result in an increase in compression and a reduction in coronary micro vascular reserve.
- Plaque formation at the bridge can exacerbate coronary occlusion caused by the bridge.
- Myocardial flow might be reduced by negative remodeling inside the bridge.

Each of these variables can have a role in the development of symptoms in individuals with myocardial bridging to varied degrees.

2.3 Management of Myocardial Bridge

There are several published management strategies for managing the myocardial bridge. However, they are all conservative. For asymptomatic cases, it is advised to maintain the cardiovascular modification and administer the usual treatments for any CAD associated with it. Available treatments for myocardial bridge are discussed below:

2.3.1 *Pharmacology Therapy*

B-blockers are the main treatment for symptomatic patients. They reduce the hemodynamic disruption induced by the myocardial bridge by shortening the diastolic coronary filling time and reducing coronary artery contractility and compression (Corban et al., 2014).

This is because individuals with myocardial bridging are at a greater risk of developing atherosclerosis, aggressive risk factor modification is recommended, and antiplatelet medication should be investigated (Corban, M, et al, 2014).

2.3.2 *Surgery*

The dissection of the heart is about superarterial myotomy and coronary artery bypass surgery (CABG). This can be done to treat this condition. However, there are possibilities for complications such as ventricular aneurysm formation and post-operative bleeding. Conversely, the major concern of CABG with regards to myocardial bridges is graft failure (Corban et al., 2014).

2.4 Related Works

(Pyung Jin et al. 2009) examined 311 patients after taking them through CT angiography and conventional angiography to determine the frequency of myocardial bridging based on the sensitivity of the two methods. The patients which were made up of 208 men and 103 women were reviewed for myocardial bridging of the left anterior descending coronary artery. They classified myocardial bridging to either myocardial bridge with full encasement or myocardial bridge with partial encasement according to vessel encasement by the myocardium. CTA discovered myocardial bridging in 58% (174) of the patients while Conventional angiography revealed dynamic compression in 13.3% (40) of the patients.

The treatment available for myocardial bridge includes medical therapy, surgery, and percutaneous coronary intervention (Lee et al., 2015). Surgical myotomy and coronary artery bypass graft surgery are two surgical options for myocardial bridging (Lee et al., 2015). The resection of underlying muscle fibers (surgical myotomy) is usually reserved for patients who have refractory symptoms particularly those with demonstrated inducible ischemia and those at risk for myocardial infarction or resuscitated cardiac arrest (Lee et al., 2015). In 1995, the first case of coronary stenting for severe bridging that was resistant to medical therapy was reported (Stables et al., 1995). Stenting has been shown in preliminary studies to resolve hemodynamic abnormalities and symptoms (Lee et al., 2015). However, multiple studies have since shown that percutaneous coronary intervention has a high rate of target lesion revascularization. In a study of 70 patients with myocardial bridging who received stents (primarily drug-eluting stents) for a proximal LAD artery lesion, rates of target lesion revascularization at 1 year were much higher (24 percent vs. 3 percent) in patients whose stents extended into the bridged segment (Lee et al., 2015).

In a study carried out in Multan, (Badar et al., 2018) Computed Tomographic (CT) was also used to test over 200 patients with mean age 51.53 years and 79.9% of them were male. Myocardial bridge was diagnosed in 8.2% of the patients. In their research, they studied the methods of (Dankol et al., 2013) and (Hwang et al., 2010) in Saudi and Korea populations respectively. Their findings show that CTA has better accuracy compared to conventional angiography when detecting myocardial bridge although, the accuracy of CTA may vary based on the equipment used for studies (Badar et al., 2018).

Extensive review of literature has been done on myocardial bridging following the recent interest in it. In (Teragawa et al., 2019) an extensive review focusing on the pathophysiology and diagnosis of myocardial bridge and its related cardiovascular diseases was carried out due to the occurrence of cases where myocardial bridge was reported as the cause of ischemic heart diseases and sudden cardiac death. Autopsy and Intravascular Ultrasound (IVUS) have led to two main pathological findings of myocardial bridge which are the presence of developing atherosclerosis at the proximal segment of myocardial bridge and the absence of atherosclerosis at the distal and intramural segments of the myocardial bridge (Teragawa et al., 2019). Also, there are some factors that affect the frequency of myocardial bridge in patients; factors such as the use of nitroglycerin. According to (Teragawa et al., 2019), the frequency of myocardial bridge varies between 5.4% and 80% of autopsy cases, 25% and 30.2% of cases evaluated using computed tomography, and 0.5% and 16% of cases evaluated using coronary angiography. Also, from the results obtained in a meta-analysis of the prevalence of myocardial bridge according to (Teragawa et al., 2019), 67% to 98% of observed cases had their location in the LAD. However, (Sternheim, et al., 2021) stated that the true prevalence of myocardial bridge is approximately 1 in 3 adults.

Other diagnostic tests for myocardial bridge include echocardiogram, myocardial perfusion imaging (MPI), intravascular ultrasound (IVUS), and fractional flow reserve (ffr). Exercise echocardiography can be used to diagnose myocardial bridge (Yukari, et al., 2015). Exercise-induced physiological changes can be a useful noninvasive method for assessing myocardial bridge. A study of septal longitudinal strain (LS) throughout exercise echocardiography in patients with IVUS confirmed LAD bridging, noticed a big reduction in LS when compared to controls (Murtaza et al., 2020). There was a correlation of exercise echocardiography findings with IVUS

and diastolic fractional flow reserve (dFFR) in documented myocardial bridging. (Murtaza et al., 2020). It was discovered that myocardial bridge causes distinct septal wall motion abnormalities, including septal buckling that spares the apex. However, before it may be utilized on a regular basis, stress echocardiography's usefulness as a diagnostic test needs to be established. MPI detects perfusion deficits substantially better than stress echocardiography wall motion abnormalities. Between 20% and 40% of perfusion problems can be found using MPI (Murtaza et al., 2020). Assessing the hemodynamic significance of the myocardial bridge and deciding the best course of treatment may be aided by stress perfusion imaging. However, MPI's diagnostic value is constrained due to its low sensitivity in detecting myocardial bridge. IVUS has been utilized to see the coronary segments in patients with angiographic signs of systolic vascular compression in the LAD artery. During the cardiac cycle, the cross-sectional shape of the bridged segment changes. On IVUS, systolic compression of the myocardial bridge results in lumen reduction and the characteristic echo lucent 'half-moon' phenomenon. Due to the low shear stress and consistent injury to the segment proximal to the myocardial bridge, atherosclerotic plaque can also be detected in segments proximal to the bridge (Murtaza et al., 2020)

Myocardial bridge was overlooked for a long time as it was thought to be safe. Since all coronary blood flow occurs during diastole, this was based on the systolic arterial compression that characterizes myocardial bridging. As a result, 15% or so of coronary blood flow is particularly prone to being compromised by significant myocardial bridge. However, the reality of myocardial bridging is more complicated and characterized by the interplay between anatomic and physiologic factors that affect each other not just during the cardiac cycle but in the lifetime (Sternheim, et al., 2021). An uncommon important cause of chest pain in patients with normal or non-significant obstructive coronary artery is coronary artery spasm which was first described by Prinzmetal (1959). The association of coronary artery spasm with myocardial bridging has been reported in (Ibarrola, 2021). Between muscle bundles and superficial bridges, there is a clear distinction. The latter arises as a result of the right ventricular apical trabeculae that cross the LAD either helically or transversely before ending in the interventricular septum. Superficial bridges can cross the artery at right angles or at an acute angle toward the peak (Ibarrola, 2021). Myocardial bridging can be observed and examined using a variety of imaging modalities, as shown in (Ibarrola, 2021). Myocardial bridges are typically diagnosed via CA, which

features the typical milking effect and a step down-step up phenomenon brought on by systolic compression of the constricted segment. Myocardial bridge is to be detected indirectly in coronary angiograms, based on systolic lumen reduction, and the milking effect may be missed. According to (Ibarrola, 2021), non-invasive imaging techniques such as Electron Beam Tomography (EBT) and Cardiac Computed Tomography Angiography (CCTA) can also be used to visualize myocardial bridging. CCTA has evolved into a valuable tool for assessing coronary anatomy and patency. CCTA has been shown in studies to detect intramyocardial segments at a much higher rate than angiography.

In a study that analyzed the morphological features of coronary anomalies, it was discovered that they can be evaluated more precisely than CCTA. Of the number of patients tested, coronary anomalies were found in 7.9 percent of CCTA patients and 2.1 percent of CA patients ($p < 0.01$). The most common coronary anomaly detected by CCTA was myocardial bridging (42.8%), followed by CA (21.2%) ($P < 0.01$). Even after excluding patients with myocardial bridging, which is more common with CCTA, the conductors of the studies concluded that the prevalence of coronary anomalies is significantly higher with CCTA than with CA (Ibarrola, 2021). The method considered as the primary imaging modality for detecting and characterizing Coronary Artery Anomalies (CAA) is the CCTA. This is because three-dimensional visualization of the entire coronary tree gives accurate depiction of the origin, course, and ending of the coronary vessels, which gives it a higher rate of detection of CAA than invasive coronary angiography and other noninvasive imaging modalities (Ibarrola, 2021).

In previous literatures, there has been no significant correlation between age and myocardial bridging as it is from birth. However, the study population of (Badar et. al. 2018) had a mean age of 51.53 years. In a similar study conducted in Japan and China, the mean age of participants was 59 years and 63 years respectively.

CHAPTER III
Materials and Methods

3.1. Study Design and Participants

During the period between 2016 and 2022, a total number of 740 radiographs of patients were collected from the Radiology department of Kyrenia University Hospital in the Turkish Republic of Northern Cyprus.

This retrospective study utilized a selection method of radiographs that showed the arteries of the heart. An informed consent form was waived due to the retrospective type of the study. Clinical data were obtained on each of the radiographs of patients.

3.2. Data Collection Tools and Material

After obtaining ethical approval from the Ethics Board of Kyrenia University Hospital, all radiographs were viewed electronically on a PACS Oasis Desktop. All radiographs of patients of all ages were considered because myocardial bridge is a congenital situation. High quality radiographs showing the myocardial bridge of the heart was used for this study.

3.3. Statistical Analysis

The data collected were evaluated statistically using One-way Anova and Statistics Package for Social Sciences (SPSS) version 24.

CHAPTER IV

Findings and Discussion

4.1 Frequency

Table 1.

Frequency of Myocardial Bridge in the Population of TRNC

Patients	**Studied Group Population (n=740)**	**%**
Myocardial bridge (+)	520	70.3
Myocardial bridge (-)	220	29.7
Total	740	100

The frequency of myocardial bridge in the sample population is shown in table 1. Myocardial bridge was found in 520 patients (70.3%) of the 740 radiographs while 220 patients were found to not have myocardial bridge which accounts for 29.7%.

4.2 Observed Myocardial Bridges and Coronary Arteries

Table 2.

Frequency of Myocardial Bridge in the Affected Coronary Arteries

Coronary Artery's Involvement	**Myocardial Bridge (n=520)**	**%**
LAD Only	159	30.58
RCA Only	126	24.23
Cx Only	15	2.88
LAD and Cx	15	2.88
LAD and RCA	147	28.27
Cx and RCA	16	3.08
LAD, Cx and RCA	42	8.08
Total	520	100.00

Myocardial bridge was found (100%). The most frequent artery with myocardial bridge in the study is LAD which was found in 159 patients (30.58%) of the 520 radiographs. RCA was found in 126 patients (24.23%), 15 (2.88%) patients were

found to have myocardial bridge of the CX. LAD and CX were found in 15 patients also which accounts for 2.88%. 147 (28.27%) patients were found to have RCA and LAD. CX and RCA were found in 16 (3.08) patients while 42 (8.08%) patients were found with myocardial bridge of the LAD, CX and RCA.

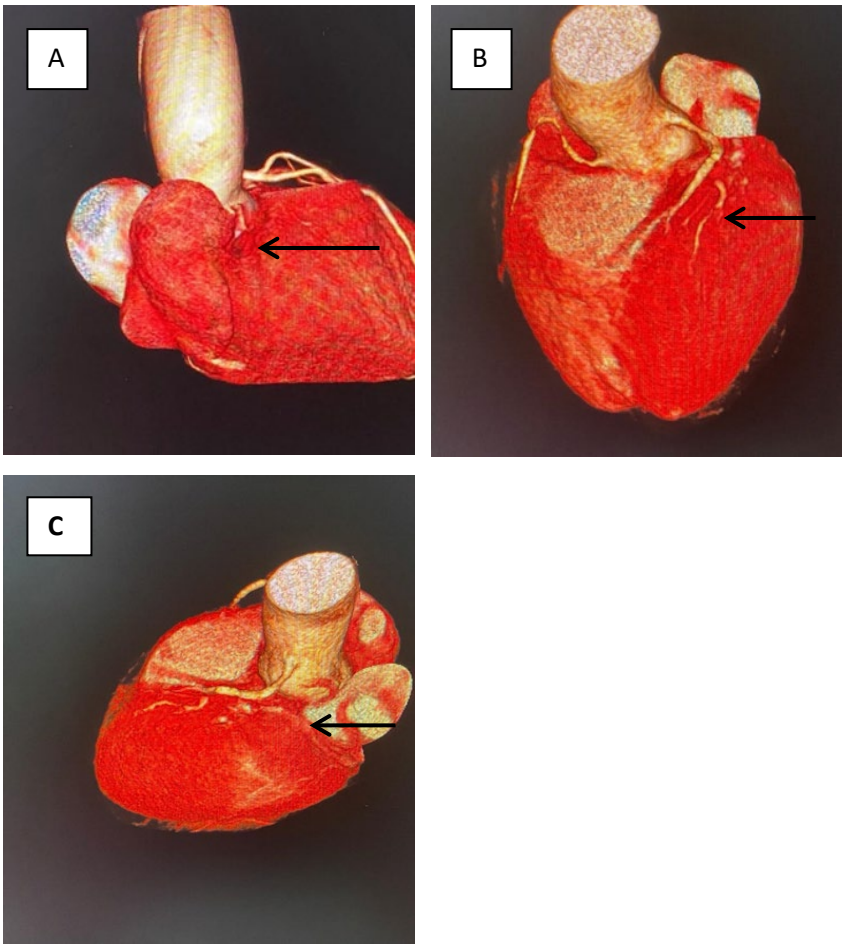


Figure 1.

Images Showing the Myocardial Bridge

A) Myocardial bridge of the RCA, (B) Myocardial bridge of the LAD, (C) Myocardial bridge of the CX

4.3 Myocardial Bridge and Gender

Table 1.

Frequency of Myocardial Bridge Based on Gender in TRNC

Gender	Population (n=740)	Myocardial bridge (+)	Myocardial bridge (-)	%
Male	465	324	141	43.7
Female	275	196	79	26.5
Total	740	520	220	70.2

The table above is segmented based on the gender of the patients. This is to determine the frequency of myocardial bridge in both genders. The frequency of myocardial bridge based on gender is assessed in two ways: The total population under study and the patients with myocardial bridge.

The frequency of myocardial bridge in males in the population under study is 43.7% and that of female is 26.5%.

Frequency of myocardial bridge in males and females in the population of people with myocardial bridge is evaluated in the table below:

Table 2.

Frequency of Myocardial Bridge Based on Gender in the Affected Patients

Gender	Frequency	%
Male	324	62.3
Females	196	37.7
Total	520	100

In the population under study in TRNC, 324 males were seen with the myocardial bridge, as well as 196 females. The percentage of males in the population with myocardial bridge is 62.3% and females are 37.7%. Males are more affected by myocardial bridge than female patients in the population under study.

Table 5.

Frequency of Arteries with Myocardial Bridge Based on Gender

Artery with Myocardial Bridge	Males (n= 324)	%	Females (n=196)	%
LAD Only	94	29	66	33.7
RCA Only	80	24.7	45	22.95
Cx Only	9	2.78	6	3.06
LAD and Cx	10	3.08	5	2.55
LAD and RCA	99	30.56	48	24.48
Cx and RCA	9	2.78	7	3.57
LAD, Cx and RCA	23	7.1	19	9.69
Total	324	100	196	100

The table above shows the frequency of arteries with myocardial bridge based on the gender. It is observed that in the total population under study in TRNC, LAD is the most frequent artery with myocardial bridge.

In males, LAD was found in 94 (29%) patients, RCA was found in 80 (24.7%), CX was found in 9 (2.78%) patients, LAD and CX were found in 10 (3.08%), LAD and RCA were found in 99 (30.56%) patients, CX and RCA were found in 9 (2.78%) patients while LAD, CX and RCA were found in 23 (7.1%) patients.

In females, LAD was found in 66 (36.7%) patients, RCA was found in 45 (22.95%) patients, CX was found in 6 (3.06%) patients, LAD and CX were found in 5 (2.55%) patients , LAD and RCA were found in 48 (24.48%) , CX and RCA were found in 7 (3.75%), LAD, CX and RCA were found in 19 (9.69%) patients.

Figure 2.

A Pie Chart Showing the Distribution of Arteries with Myocardial Bridge in Males

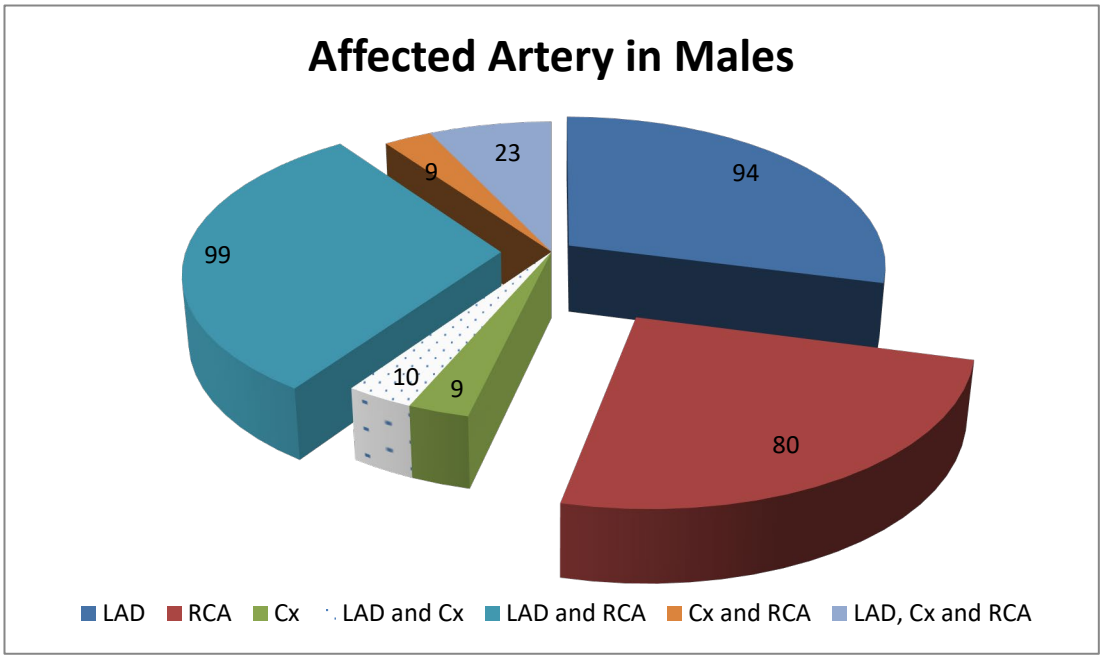
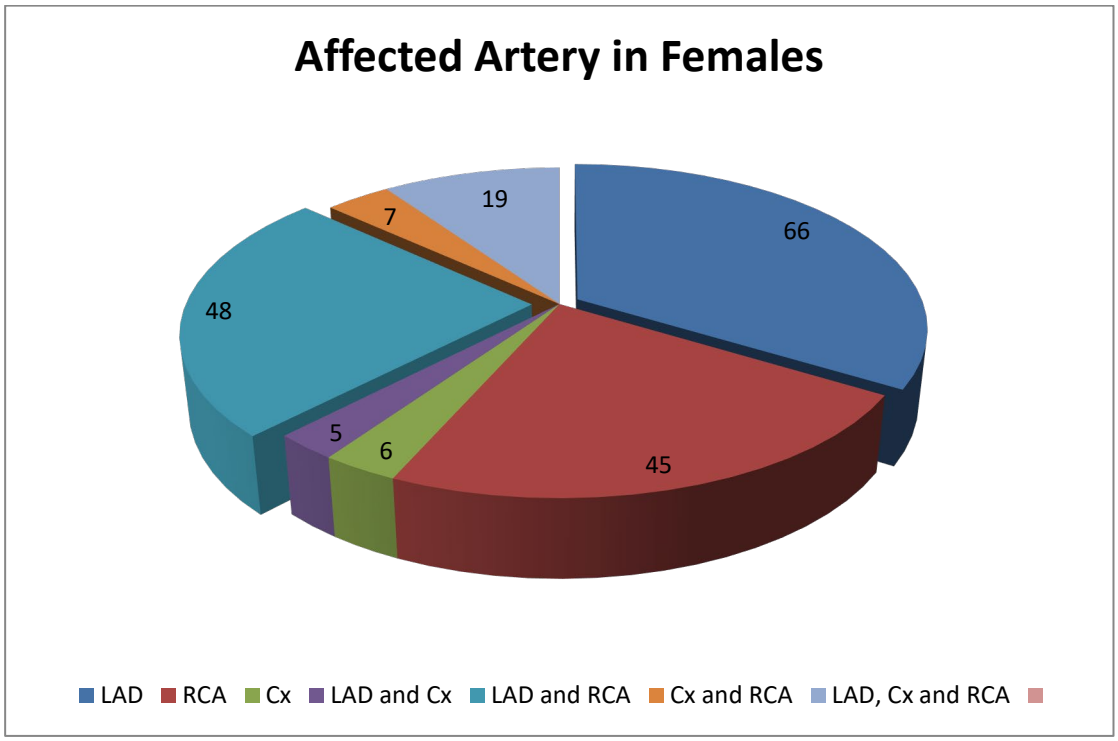


Figure 3.

A Pie Chart Showing the Distribution of Arteries with Myocardial Bridge in Females



CHAPTER V
Discussion

It has been established from our study using descriptive statistics that the frequency of myocardial bridge in the sample population (TRNC) is 70.3% (Table, 1; Figure, 1). Myocardial bridges are usually diagnosed via computed tomography (CT), intravascular ultrasound (IVUS), autopsy and/or cadaver dissections (Ibarrola, 2021). The methodology used in diagnosis can affect the frequency of myocardial bridge in the population under study. Myocardial bridges can easily be obscured by pericardial fat, such that it is not easily detected by any means of diagnosis (Rogers, I. et al., 2017). Literatures of related research have found frequency of myocardial bridge in their study population to be within the range 0.6 – 85%, such as 55.6% frequency in a study of 90 hearts (Ferreira Jr, et al., 1991). The large variation in the frequency across literatures is a factor of the diagnostic methodology. Frequency at autopsy largely differs from frequency at angiography. (Möhlenkamp, Hort, Ge, & Erbel, 2002) curated a variety of study on autopsy-based diagnosis of myocardial bridges and found that the average frequency is 38.6%, while angiography-based diagnosis accounted for an average frequency of 7% in total.

Rogers et al., (2017) discovered in a study that included 1056 subjects, a frequency of 26% with the LAD accounting for 86% of artery with myocardial bridging. Another population-based study using CT resulted in a frequency and, due to this and some other reports, Rogers et al., (2017) estimated that 25% is the generally accepted frequency.

Table 6.

Comparison of Frequency of Myocardial Bridge with Other Literatures Based on Diagnostic Method

	Overall Frequency (%)	**Autopsy (%)**	**Tomography (%)**	**Coronary Angiography (%)**
This study	70.27	-	-	-
(Hostiuc, et al. 2017)	19	42	22	6
(Matta, et al., 2021)	1.42	-	-	1.42
(Aiyappan, Vadanika, Karpagam, Vinayagam, & & Saravanan, 2015)	3.6	-	-	3.6
(Shabestari, Akhlaghpoor, Tayebivaljozi, & Fattahi Masrour, 2012)	21.3	-	21.3	-
(Dogan, et al., 2016)	8.3	-	8.3	-
Eftekhar-Vaghefi et al., 2019	100	-	100	34
Ghadri et al., 2014	42.8	-	42.8	21.2
Jukić et al., 2017	48	-	48	-
Altin et al., 2015	1.1	-	-	1.1
Chourasiya et al., 2020	4.77	-	-	4.77
Lee et al., 2014	17.1	-	-	17.1
Pelliccia et al., 2016	0.1	-	-	0.1
Sun et al., 2013	12.3	-	-	12.3
Tripathy et al., 2015	40.4	-	-	40.4
Wang et al., 2015	2.0	-	-	2.0
Akishima-Fukasawa et al., 2018	62	-	-	62
Cukuranovic et al., 2019	54	-	-	54
Loukas et al., 2014	36.8	36.8	-	-

Some of the articles examined adopted a single modality in determining the presence of myocardial bridges while others used more. We can establish from this comparison that the frequency is a factor of the modality.

In our study, the diagnostic methodology was not collected as part of the data. However, with a frequency of approximately 70.3% in a sample of 740 people, it is assumed that the diagnostic methodology is extremely sensitive. The bridges can be "deep" or both (“superficial” and “deep”). Consequently, the definition given to myocardial bridge has a large impact on the determination of its frequency. According to an analysis of different studies, the number of myocardial bridges between genders differs significantly. In our study, they were found to be 24.6% more frequent in males than in females (Table, 3; Figure, 2). This difference could be biased for a variety of reasons, and this would require further investigation. Some of these factors include; a higher frequency of arterial hypertension and left ventricular hypertrophy in males, hypertrophic cardiomyopathy (HCM) in patients

Myocardial bridging can be found in any of the arteries, but it is most common in the LAD (Roberts et al., 2021). Obviously, from our study, the most prevalent artery is the LAD, accounting for 30.58% of the entire population (Table, 2). This is followed by the RCA occurring as the second common artery where myocardial bridging occurs in the population, while myocardial brigding is rarely found in the circumflex arteries (Cx). In addition, more than one artery was affected (LAD and RCA) in 28.27% of the patients, while other occurrences of myocardial bridging were found in the LAD and Cx (2.88%).

Finally, the RCA and Cx were found to be affected in 3.08% of the total population, LAD, Cx, and RCA were affected altogether in about 8.08% of the patients (Table, 2).

CHAPTER VI

Conclusion and Recommendation

6.1 Conclusion

In conclusion, myocardial bridge can be benign because it is not detected except in autopsies in some cases, it may cause myocardial ischemia, which may lead to anginal symptoms such as chest pain and shortness of breath, acute coronary syndrome, cardiac arrhythmias and rarely sudden cardiac death (Ghulam et al 2020). In this study, we have examined the frequency of myocardial bridges in the population of TRNC by analyzing samples of 740 patients. After the analysis, it has been discovered that the frequency of myocardial bridge is 70.3% in our study sample. It is more prevalent in males than in females and it mostly occurs in the left anterior descending artery (LAD) and is least found in the circumflex artery (Cx). We have established a comprehensive statistical understanding of the frequency of myocardial bridge in the study population.

6.2 Recommendation

This study also recommends that further studies should be conducted to establish a significant understanding of the pathology of myocardial bridge based on gender. The study and other related literatures established that myocardial bridge is more frequent in males than in females, further studies conducted should ask the question: why is myocardial bridge more frequent in males than females?

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Appendices

Appendix A

30/08/2022

Dr. Suat Gunsel University of Kyrenia Hospital.

Assoc. Prof. Dr. Mehmet Alp Dirik of the Radiology Department of Kyrenia University Hospital.

This is to ascertain that Eunice Tiwaloluwa Olawale of Near East University, Department of Anatomy, Lefkosa, with student number 20195690 was granted permission to access the CT archives of patients from 2016-2022 from the radiology department of the hospital for the purpose of completing her master's thesis (FREQUENCY OF MYOCARDIAL BRIDGE IN THE POPULATION OF TURKISH REPUBLIC OF NORTHERN CYPRUS).

Assoc. Prof. Dr. Mehmet Alp Dirik

Signature:

Appendix B

Turnitin Similarity Report

Appendix C

CV

OLAWALE EUNICE TIWALOLUWA

PERSONAL

Address: 13, Sht. Kemal Arikan Sk, Lefkosa 99010 Nicosia, Cyprus
Telephone: +2348101282611
Gmail: teewaloluwa@gmail.com
Date of birth: 15th June 1997

PROFILE

An independent graduate with a second class lower degree in Human Anatomy, keen to commence my career as an Anatomist and also an health care worker. I am self-motivated, a good team player, committed and determined in achieving my goals. I would like to getinvolved with tasks that will challenge me to utilize and develop my skills in this field. I would also like to go into other areas of specialization in order to acquire more skills as I can work in any field or organization.

EDUCATION

Near East University February 2020, Nicosia, Cyprus
Human Anatomy (Masters in view)

Bowen University 2014-2018, Osun State, Nigeria
B.SC Human Anatomy
Grade: Second Class Lower (2.2)
Dissertation: Effect of dihydrocodeine on the hypothalamus of male wistar rats. Dihydrocodeine was administered to the male wister rats for three weeks and were sacrificed afterwards to harvest the hypothalamus for observation histologically. It was discovered that dihydrocodeine had adverse effect on the hypothalamus. I had a distinction.

PROFESSIONAL TRAINING

Dexter & Heroes Consulting Abuja, Nigeria

Project Management and Planning January 2019

Health Safety and Environment January 2019

Human Resource Management January 2019

Introduction to care giving March 2022

WORK EXPERIENCE

Near East University March 2020 – Present; Nicosia, Cyprus

Laboratory assistant

- Assisting during lab sections

National youth service Corps (NYSC) November, 2018 – October 2019; Abuja, Nigeria

Office of the Senior Special Assistant to the President on Sustainable Development Goals.

- Learnt the file cabinet system.
- Learnt how to start up a registry in an organization and maintain it.
- Receiving and dispatching of mails and contracts.
- Liaising with other departments.

ADDITIONAL SKILLS AND INTERESTS

IT skills: Basic knowledge in HTML

Interests: Learning new things, trying new foods and reviewing, adventures, listening to music and proofreading.

Appendix D

Waived Informed Consent Form

INFORMED CONSENT FORM FOR ADULTS

(FOR THE PATIENTS / PARTICIPANTS)

You are invited to participate in a research study conducted by [name of investigator(s)], from the NEAREAST UNIVERSITY [departmental affiliation(s)]. I have learned that [state what the study is designed to discover or establish]. You were selected as a possible participant in this study because [state why the subject was selected].If you decide to participate, [describe procedures, including their purpose, how long they will last, their location and frequency. If activities are to be audio or videotaped, indicate this]. [Describe risks, discomforts, inconveniences, and how these will be managed. Describe any alternative procedures or courses of treatment, if applicable. Indicate costs of participating, if any]. [Describe benefits to subjects and humanity expected from the research]. However, I cannot guarantee that youpersonally will receive any benefits from this research. [If subject will receive compensation, describe amount and when payment is scheduled].Any information that is obtained in connection with this study and that can be identified with you willremain confidential and will be disclosed only with your permission or as required by law. Subjectidentities will be kept confidential by [describe coding procedures and plans to safeguard data]. [If participants will remain anonymous, then reword the above to reflect that and state how the information will be kept anonymous.] [If information will be released to any other, for any reason, state the personal agency to whom the information will be furnished, the nature of the information, and the purpose of the disclosure].Your participation is voluntary. Your decision whether or not to participate will not affect yourrelationship with [name agency, school, etc. where subject was recruited]. If you decide to participate,you are free to withdraw your consent and discontinue participation at any time without penalty. If you have any questions about the study, please feel free to contact [phone number, e-mail, and address]. [If student, also provide advisor name and phone, and identify as your advisor]. If you havequestions regarding your rights as a research subject, please contact the NEAR EAST INSTITUTIONALREVIEW BOARD. You will be offered a copy of this form to keep.Your signature indicates that you have read and understand the information provided above, that youwillingly agree to

participate, that you may withdraw your consent at any time and discontinueparticipation without penalty, that you will receive a copy of this form, and that you are not waiving anylegal claims.

Participant

Name, Surname:

Address:

Phone:

Signature:

Witness

Name, Surname:

Address:

Phone:

Signature:

Interviewer:

Name, Surname:

Address:

Phone:

Signature:

Appendix E

Criteria Table

Patient No	Gender	Age	Coronary Arteries	MB (+/-)	MB+ (Segments)