A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF ÇANKIRI KARATEKİN UNIVERSITY

ASSESSMENT OF THE LEVELS OF TUMOR NECROSIS FACTOR-ALPHA AND OTHER PARAMETERS IN PATIENTS WITH ACUTE MYOCARDIAL INFARCTION IN BAGHDAD CITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
CHEMISTRY

BY

MOHAMMED MUNEER NOORI AL-JANABI

ÇANKIRI

2023

ASSESSMENT OF THE LEVELS OF TUMOR NECROSIS FACTOR-ALPHA AND OTHER PARAMETERS IN PATIENTS WITH ACUTE MYOCARDIAL INFARCTION IN BAGHDAD CITY

By Mohammed Muneer Noori AL-JANABI

June 2023

We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science

Advisor **:** Assoc. Prof. Dr. Şevki ADEM

Examining Committee Members:

Chairman **:** Prof. Dr. Volkan EYÜPOĞLU
Chemistry
Çankırı Karatekin University

Member **:** Asst. Prof. Dr. Ümit YIRTICI
Medical Laboratory
Kırıkkale University

Member **:** Assoc. Prof. Dr. Şevki ADEM
Chemistry
Çankırı Karatekin University

Approved for the Graduate School of Natural and Applied Sciences

Prof. Dr. Hamit ALYAR
Director of Graduate School

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Mohammed Muneer Noori AL-JANABI

ABSTRACT

ASSESSMENT OF THE LEVELS OF TUMOR NECROSIS FACTOR-ALPHA AND OTHER PARAMETERS IN PATIENTS WITH ACUTE MYOCARDIAL INFARCTION IN BAGHDAD CITY

Mohammed Muneer Noori AL-JANABI

Master of Science in Chemistry

Advisor: Assoc. Prof. Dr. Şevki ADEM

June 2023

Myocardial infraction is a serious condition of the heart that leads to life threatening events. In this study, 160 subject were enrolled and examined for their levels of creatine kinase, troponin t, tumor necrosis factor alpha, artery natriuretic protein, lactate dehydrogenase, and aspartate aminotransferase. Patients with myocardial infraction have shown significant increase of creatine kinase (CK), troponin t, tumor necrosis factor alpha (TNFα), Atrial natriuretic peptide (ANP), lactate dehydrogenase (LDH) and aspartate aminotransferase (AST). All of the biomarkers were increased significantly in male patients, while female patients have shown non-significant change of ANP level. Additionally, CK was correlated positively with troponin t and TNFα indicating that these parameters have strong association with myocardial infraction. Moreover, TNFα has shown excellent sensitivity in the prognosis of myocardial infraction disease, while ANP has failed to become a biomarker for myocardial infraction disease.

2023, 65 pages

Keywords: Acute myocardial infarction, Tumor necrosis factor-alpha, ANP, CRP

ÖZET

BAĞDAT ŞEHİRİNDEKİ AKUT MYOKARDİAL ENFARKSİYONLU HASTALARDA TÜMÖR NEKROZ FAKTÖR-ALFA VE DİĞER PARAMETRE DÜZEYLERİNİN DEĞERLENDİRİLMESİ

Mohammed Muneer Noori AL-JANABI
Kimya, Yüksek Lisans
Tez Danışmanı: Doç. Dr. Şevki ADEM
Haziran 2023

Miyokard enfarktüsü, hayatı tehdit eden olaylara yol açan ciddi bir kalp hastalığıdır. Bu çalışmada 160 kişi kaydedilmiş ve kreatin kinaz, troponin t, tümör nekroz faktörü alfa, arter natriüretik protein, laktat dehidrojenaz ve aspartat aminotransferaz seviyeleri açısından incelenmiştir. Miyokard enfarktüsü olan hastalarda kreatin kinaz (CK), troponin t, tümör nekroz faktörü alfa (TNFα), Atriyal natriüretik peptid (ANP), laktat dehidrogenaz (LDH) ve aspartat aminotransferaz (AST)'de önemli artışlar görülmüştür. Tüm biyobelirteçler erkek hastalarda önemli ölçüde artarken, kadın hastalarda ANP seviyesinde anlamlı olmayan bir değişiklik görülmüştür. Ek olarak, CK, troponin t ve (TNFα) ile pozitif korelasyona sahipti ve bu parametrelerin miyokard enfarktüsü ile güçlü bir ilişkisi olduğunu gösteriyor. Ayrıca (TNFα), miyokard enfarktüsü hastalığının prognozunda mükemmel bir duyarlılık gösterirken ANP, miyokardiyal enfraksiyon hastalığı için bir biyobelirteç olmayı başaramadı.

2023, 65 sayfa

Anahtar Kelimeler: Akut miyokard enfarktüsü, Tümör nekroz faktörü-alfa, ANP, CRP

PREFACE AND ACKNOWLEDGEMENTS

I would like to thank my thesis advisor, Assoc. Prof. Dr. Şevki ADEM, for his patience, guidance and understanding.

Mohammed Muneer Noori AL-JANABI
Çankırı-2023

CONTENTS

LIST OF SYMBOLS

dL	Deciliter
°C	Degrees Celsius
g	Gram
kDa	Kilodalton
L	Liter
µg	Microgram
µL	Microliter
µIU	Microliter International Unit
mg	Milligram
mL	Milliliter
nm	Nanometer
nmol	Nanomole
%	Percent
pg	Picogram
±	Plus – minus
rpm	Revolution per minute

LIST OF ABBREVIATIONS

AMI	Acute myocardial infarction
ANP	Atrial natriuretic peptide
AST	Aspartate aminotransferase
CK	Creatine kinase
CRP	C-reactive protein
ECG	Electrocardiogram
LDH	Lactate dehydrogenase
LV	Left ventricle
MI	Myocardial infarction
PCI	Percutaneous coronary intervention
PVI	Percutaneous coronary intervention
TNFα	Tumor necrosis factor alpha
URL	Upper reference limit

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Over the last 40 years, researchers have made great strides in pinpointing AMI's origins and developing effective treatments. Autopsy was the only reliable method of diagnosing AMI in the early 20th century. Up until the 1970s, when its typical clinical appearance and diagnosis were well understood, it was treated conservatively by prescribing bed rest and a sedentary lifestyle for the patient. There has been a deluge of new data since then, completely reshaping our knowledge of the disease's pathophysiology and our ability to effectively treat it. In this post, we'll look back at how far we've come in our knowledge of this crucial disorder and how we're currently treating it.

Myocardial necrosis due to an unstable ischemia state is what we call an acute myocardial infarction. Diagnosis and assessment in clinical practice may use a variety of methods, including but not limited to: clinical examination; electrocardiogram; biochemical testing; invasive and noninvasive imaging; and pathological evaluation (Thygesen *et al.* 2018).

Acute myocardial infarction can be classified into four different types: type 1, which is caused by coronary atherothrombosis; type 2, which is not caused by acute atherothrombosis but rather a supply-demand mismatch; type 3, which causes sudden cardiac death without the chance for biomarker or ECG confirmation; and type 4, which is related to a percutaneous coronary intervention (PVI) (Anderson and Morrow 2017).

TNF-α has various impacts on all cells during cardiac tissue damage and healing. Increases apoptosis in cardiomyocytes, decreases cardiac contractility, and upregulates chemokine, adhesion molecule, and leukocyte expression (Ohta *et al.* 2005). By increasing matrix metalloproteinases activity and lowering collagen production, it controls extracellular metabolism in cardiac fibroblasts. TNF-alpha is increased in persons with insulin resistance and blocks the signaling of insulin-stimulated receptors (Wang *et al.* 2018). TNF-alpha in ischemic myocardium may cause either angiogenesis or connective tissue growth, leading to scar formation, depending on the dosage. Patients with coronary artery disease, and particularly in areas of damaged plaque, have been reported to have elevated levels of TNF-α. Abnormal contractile activity in myocytes is caused by the production of pro-inflammatory cytokines (Ohta *et al.* 2005) called TNF-α. Damage caused by TNF-alpha may be stopped or even reversed by binding receptors. Similar to ischemic pre-conditioning, pre-treatment with TNF-alphaantibody may reduce the size of the myocardial infarct.

In addition to acting as a circulating hormone, the natriuretic peptide atrial natriuretic peptide (ANP) may also serve as an autocrine and/or paracrine component in the atrium to protect the heart. Studies have revealed that ANP decreases infarct size and prevents IR harm. Furthermore, ANP may bind to natriuretic peptide receptors (NPRs) that are highly abundant in the ischemic heart's endocardium (Gaudin *et al.* 2014).

Elevated CRP levels independently predict cardiac mortality, AMI, and congestive heart failure, making CRP a helpful prognostic indication in patients with AMI. In everyday clinical settings, it is the gold standard for measuring inflammation. However, compared to troponin, CRP is a less specific and sensitive indicator of heart damage. Patients with cardiac disease, such as MI and ACS (De-Servi *et al.* 2005), are often evaluated with hs-CRP in both outpatient and inpatient settings. Creatine kinase (CK) and lactate dehydrogenase (LDH) were both identified in the years that followed, with the former serving as a more sensitive and specific biomarker. Specificity, however, remained an issue, particularly for individuals suffering from muscle and liver illness or damage. Newer, more sensitive techniques of detection allowed CK-MB's superior diagnostic accuracy to be determined. The specificity of CK, LDH, and CK-MB in diagnosing AMI remains low, unfortunately (Chen *et al.* 2019, Wang *et al.* 2020)

The goal of this research is to provide a precise measurement of TNF-alpha and ANP in individuals who have had a myocardial infarction. We also demonstrate the correlation between TNF alpha, ANP, and TnT and the other parameters for which values were determined.

2. LITERATURE REVIEW

2.1 Cardiovascular Diseases

Ischemic heart disease is the main cause of mortality globally, accounting for as much as 49.2% of all cardiovascular disease deaths in 2019 (Roth *et al.* 2020). Acute myocardial infarction (MI) is defined by a sudden decrease in blood supply to the myocardium, resulting to heart failure and mortality (Mensah *et al.* 2019). This situation may be caused by thrombus blocking blood flow in an artery or bypass graft. It is generally agreed that reviving hypoxic-ischemic tissue by increasing blood flow is an effective way to prevent tissue death (Doenst *et al.* 2019). Acute myocardial infarction (MI) is often treated with thrombolysis, percutaneous coronary intervention (PCI), or coronary artery bypass grafting, as reported by the majority of clinical studies. Complications such as bleeding, ischemia-reperfusion damage, and coronary restenosis are possible, although their occurrence is unexpected (McCarthy *et al.* 2018; Sabatine *et al.* 2021). Therefore, novel and efficient strategies to maintain myocardial function and prevent heart failure progression must be actively sought.

2.2 Acute Myocardial Infarction

The traditional "heart attack," or acute myocardial infarction (MI), occurs when a coronary artery suddenly becomes completely blocked, starving the heart muscle of blood and oxygen. Myocardial injury is accompanied by well-documented alterations in risk factors, clinical presentation, electrocardiogram (ECG), and serologic markers. Although it should be used with caution, echocardiography serves a crucial purpose in the early diagnosis and management of the patient for the physician and technician. Candidates for echocardiography in the setting of suspected acute MI include those with acute chest pain, suspected MI, but a nondiagnostic ECG (especially if the scan can be performed during pain), those with recent chest pain and other features or laboratory markers indicative of ongoing myocardial infarction who are currently chest pain-free, and those being evaluated for a suspected complication of MI, such as myocardial or valve disruption. In the acute setting, when the attention should be moving towards definitive therapy (i.e., opening the coronary artery), an echo is not needed when the patient's symptoms and electrocardiogram (ECG) are strongly indicative of a continued acute MI. Suspicious cases may benefit from an early echocardiogram, especially those involving women, those with diabetes, and the elderly. Acute myocardial infarction (presentation within 48 hours) imaging requires careful consideration of numerous parameters, including diagnosis, ventricular function, and the identification of critical repercussions (Barberi and Van-Den Hondel 2018).

Injured myocardial after MI exhibits overlapping stages of inflammation, fibrosis, and angiogenesis (Wu *et al.* 2021). In the hours and days after ischemia-hypoxia, apoptotic cardiomyocytes disperse throughout the injured tissue, setting off an inflammatory response that culminates in the creation of granulation tissue with the influx of immunocytes that release pro-inflammatory cytokines and chemokines (Viola *et al.* 2021). Fibroblast collagen synthesis and endothelial cell activation are promoted by the pro-angiogenic kinases phosphoinositide-3 kinase/protein kinase B (PI3K/Akt), Janus kinase/signal transducer and activator of transcription (JAK/STAT), and transforming growth factor-beta (TGF-beta) (Jung *et al.* 2019). In addition to bringing oxygen and nutrients to the area around the infarct, the new capillaries fuel the differentiation of fibroblasts into myofibroblasts, a cell type essential for compensating for structural heart damage. Myofibroblasts increase cell survival by simultaneously activating TGF-beta and Wnt/beta-catenin signaling (Fan and Kassiri 2021). The malfunction of the heart is a result of cardiac remodeling and reactive fibrosis (Jiang *et al.* 2021).

In particular, pathophysiological states are regulated by certain cell signaling pathways. Nuclear factor, Notch, and the Sonic Hedgehog connected to erythroid 2 Some of the cell signaling pathways that control cell survival, proliferation, apoptosis, and differentiation include Nrf2/heme oxygenase-1 (Nrf2/HO-1), Ras homolog family member A/Rho-associated coiled-coil containing protein kinase (RhoA/ROCK), and others (Contessotto and Pandit 2021, Xiao *et al.* 2015). Understanding the mechanism of post-MI pathophysiological events requires thinking of cell signaling pathways as a regulatory network that participates in a wide range of functions. The discovery of the central role of signaling pathways in the progression of MI from studies of signal transduction in molecular processes has stimulated the development of innovative treatment approaches.

2.2.1 Classification of myocardial injury and infarction

An elevation in cardiac troponin concentration with at least one value greater than the 99th percentile upper reference limit (URL) may be indicative of myocardial damage. Depending on the rate of change in cardiac troponin concentration, this phrase may refer to either acute or chronic myocardial damage, regardless of the underlying cause. A 20% relative increase or decrease in troponin concentration is often employed (Chapman *et al.* 2020).

Patients having symptoms or signs of myocardial ischaemia on the electrocardiogram (ECG), or novel imaging evidence of a regional wall motion abnormality in a coronary area, are diagnosed with myocardial infarction when acute myocardial damage occurs. There are five distinct forms of myocardial infarction, as described by (Chapman *et al.* 2020, Chapman *et al.* 2017). Type 1 myocardial infarction occurs when a ruptured atherosclerotic plaque leads to turbulent blood flow, platelet aggregation, and coronary artery obstruction, resulting in myocardial ischaemia and infarction. Understanding this trait and implementing primary and secondary preventive strategies based on evidence has been shown to enhance clinical outcomes (Jobs *et al.* 2021). In the absence of atherosclerotic plaque rupture, an imbalance between oxygen supply and demand causes type 2 myocardial infarction. This often happens in the setting of some kind of physiological stress, including a rapid heartbeat, low blood oxygen levels, or a drop in blood pressure. The clinical consequences are far worse than those associated with myocardial infarction of type 1. This may be due to inadequate care for underlying coronary and structural heart disease (DeFilippis *et al.* 2019, Chapman *et al.* 2018), while patient age and comorbidities may play a role. Sudden cardiac death without biomarker sample characterizes a type 3 myocardial infarction. Percutaneous coronary intervention (4a), stent thrombosis (4b), and in-stent restenosis (4c) all lead to myocardial infarctions of type 4. Myocardial infarction of the fifth kind develops after cardiac operations.

2.2.2 Pathophysiology of acute myocardial infarction

When plaque ruptures and an occlusive thrombus forms in an epicardial coronary artery, it causes a loss of cardiac myocytes and a decline in heart function, symptoms known as acute myocardial infarction (MI). Acute mortality from MI has been reduced thanks to reperfusion strategies, but improved patient survival has led to an increase in the incidence of chronic heart failure. This is largely attributable to adverse remodeling of the damaged left ventricle (LV) following the initial ischemic event (Ibáñez *et al.* 2015). Many patients who make it through an initial MI go on to develop heart failure, a condition for which there are currently few medication choices that address the basic problem of cardiomyocyte loss, leading to a significant deterioration in quality of life. This shift in perspective has redirected translational research toward investigating post-MI consequences in an effort to discover novel strategies for reducing adverse remodeling of the left ventricle (LV) and avoiding heart failure.

Recent research in this field has shown that the innate immune system orchestrates a time-dependent cascade of events that regulates heart healing after MI (Figure 1A). The myocardium experiences severe sterile inflammation and infiltration of many immune cell subtypes, such as neutrophils and monocytes, during the first few days following MI (Figure 1B) (Prabhu and Frangogiannis, 2016). A reparative and proliferative phase follows the inflammatory reaction, during which myofibroblasts proliferate, collagen is deposited, and scar tissue is formed. ECM cross-linking and myofibroblast quiescence define the last stage of scar formation. It takes cooperation between the inflammatory, proliferative, and maturation stages of wound healing for the wound to close effectively. As was discussed before (Finckh *et al.* 2000), an excessively large or long inflammatory phase promotes the development of adverse LV remodeling, which is characterized by infarct growth, chamber dilatation, and contractile dysfunction. Indeed, a number of studies, both experimental and clinical (Majmudar *et al.* 2013, Mariani *et al.* 2006), demonstrate that an influx of inflammatory cells hinders healing after MI and is associated with adverse outcomes. With the expectation that this knowledge may lead to treatment techniques that maximize healing of the damaged heart after MI, research into the biological processes underlying the inflammatory, proliferative, and maturation stages of cardiac repair has risen. Glycans play a crucial role in leukocyte-endothelial cell adhesion processes and are valuable indicators of metabolic change, hence they are an essential aspect of such investigations. The following information elaborates on the three stages of recovery after an acute MI.

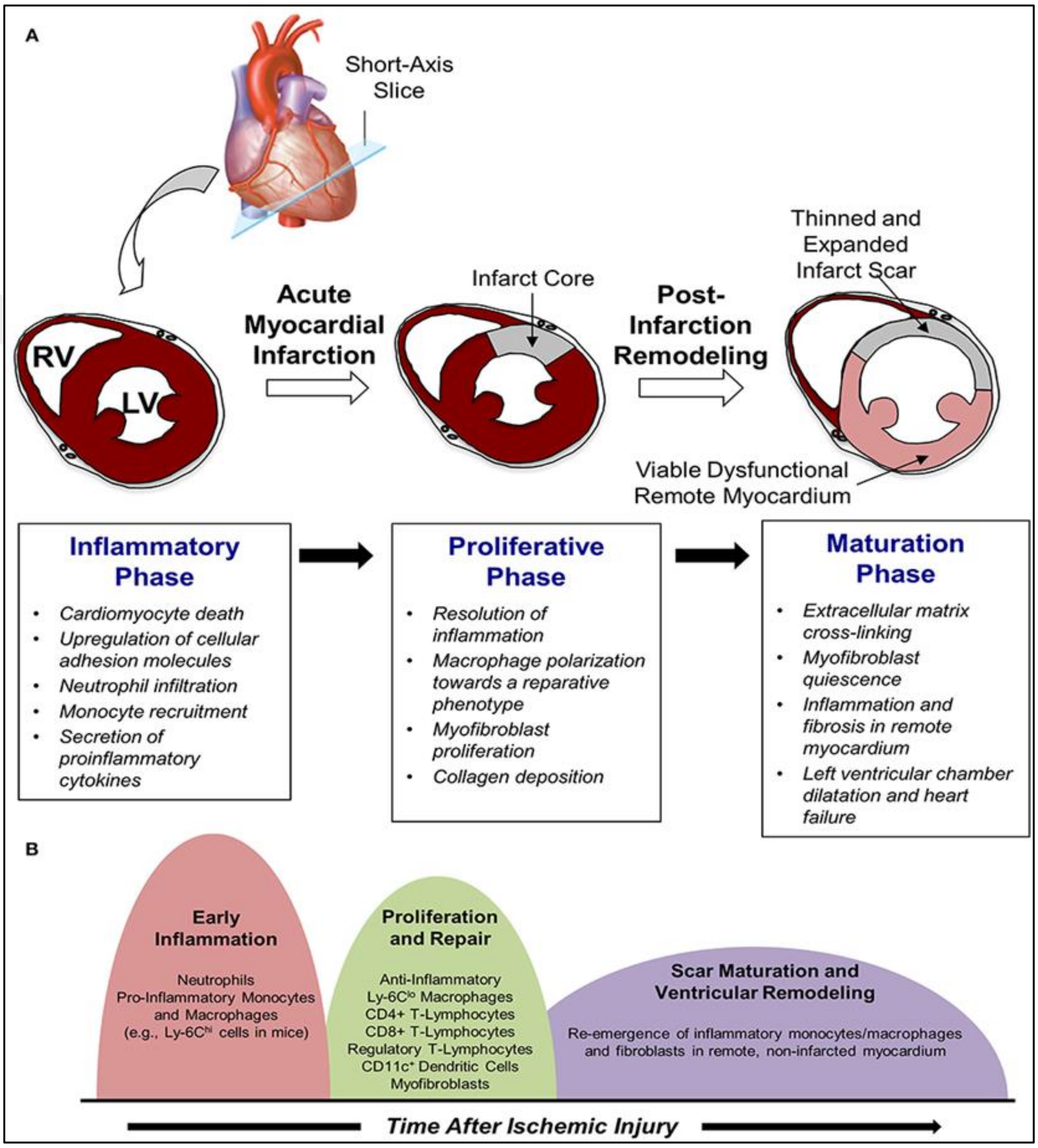

Figure 2.1 Restoring heart function after a heart attack. (A) The three stages of fixing something. (B) Leukocyte population dynamics over time during tissue healing (Weil and Neelamegham 2019)

2.2.3 Symptoms and signs of acute myocardial infarction (MI)

Both NSTEMI and STEMI present with the similar symptoms. About two-thirds of patients suffer prodromal symptoms, such as unstable or crescendo angina, shortness of breath, and exhaustion, days to weeks before the event (Babaieasl 2018).

Deep, substernal, visceral discomfort, typically characterized as aching or pressure, and spreading to the back, jaw, left arm, right arm, shoulders, or both, is generally the first sign of infarction. In contrast to angina pectoris, the pain associated with this condition tends to be more acute and persist longer, as well as to be accompanied by dyspnea, diaphoresis, nausea, and/or vomiting, and to be eased little or only briefly by rest or nitroglycerin. Nonetheless, some people with diabetes may have relatively little pain; roughly 20% of acute MIs are silent (i.e. asymptomatic or presenting nonspecific symptoms not recognized as sickness by the patient). Patients often diagnose themselves with indigestion, especially if they get temporary relief after belching or taking an antacid (Body *et al.* 2010).

Patients may appear with syncope in certain cases. Atypical chest pain is more often experienced by women. Dyspnea may be more common in elderly persons than ischemic chest discomfort (Bruyninckx *et al.* 2008).

Pain, restlessness, and anxiety are common symptoms of severe ischemia attacks. In the case of inferior MI, nausea and vomiting are common symptoms. It is possible for dyspnea and weakness to predominate in cases of LV failure, pulmonary edema, shock, or severe arrhythmia (Yu *et al.* 2023).

The skin may seem wan, cold, and perspiring. Cyanosis may manifest as either peripherally or centrally. Many patients first experience some degree of hypertension during pain, despite the fact that their pulse may be weak and their blood pressure unpredictable (Fischman *et al.* 2023).

The sounds of the heart are frequently heard from a fair distance away, and there is nearly always a fourth heart sound present. The malfunction of the papillary muscles might cause a quiet systolic blown apical murmur. Indicators of a prior heart condition or other diagnoses include a friction rub or one or more pronounced murmurs heard during the first physical examination. As opposed to a heart attack, acute pericarditis is more likely to be diagnosed if a friction rub is seen within a few hours after the commencement of symptoms. However, on days 2 and 3 after an ST-elevation myocardial infarction, ephemeral friction rubs are typical. In around 15% of people, the breast wall is delicate to the touch. Clear lung fields, hypotension, and an increase in RV filling pressure are all symptoms of right ventricular (RV) infarction (O'Rourke and Dell'Italia 2004).

2.2.4 Diagnosis

Myocardial infarction was redefined in 2012 by a joint task group of prominent medical organizations to include any cause of myocardial ischaemia that directly results in cardiac myocyte cell death (Reddy *et al.* 2015). Myocardial infarction may only be diagnosed with the presence of biomarkers for myocyte necrosis and either electrocardiographic (ECG) criteria of ischaemia or infarction or ischemic symptoms, or both (Libby 2013, Stone *et al.* 2014).

Cardiac troponin (cTn) isoforms I and T have emerged as the key diagnostic biomarkers due to their sensitivity and specificity for myocardial injury, their rapid detection time (within 2-3 h) and their peak concentration (within 24-28 h) (Storrow *et al.* 2007). High-sensitivity cardiac troponin T (hs-cTnT) has led to a 20% increase in the diagnosis of NSTEMI and a corresponding 20% reduction in the detection of unstable angina.9 To rule out NSTEMI, the European Society of Cardiology (ESC) recommends using the change in hs-cTnT within 1 or 3 hours, as stated in their 2015 NSTE-ACS guidelines. The negative predictive value for myocardial infarction in individuals with hs-cTnT below the upper limit of normal on two consecutive examinations at least 1 h apart may reach 98%, with a positive predictive value of 7580% (Peteiro and Bouzas-Mosquera

2017). However, this is outside the scope of the present review. The hs-cTnT tests have been authorized in Europe but not the United States.

cTn is emphasized by both European and American guidelines as the preferred biomarker for diagnosis of acute myocardial infarction (Rahmani *et al.* 2020), despite the fact that a CK-MB to total CK ratio of 2.5% or more is specific for myocardial injury but relatively insensitive for detecting small myocardial infarctions. One important problem is that cTn has a very long half-life in the circulation, as much as 10 days or more in patients with renal failure. Serial cTn may not detect early ischemic episodes unless cTn is falling and then increasing, or is consistently high despite an expected reduction. Although CK-MB may be used to detect myocardial damage that has already occurred, it is not as sensitive as cTn and may fail to detect very small infarctions that have already occurred.

2.2.5 Risk factors for mechanical complications

Over the last 30 years, fatality rates from AMI have decreased because to advances in prompt reperfusion within regionalized systems of care and appropriate medical therapy (Rogers *et al.* 2008). However, the aging of the US population and the increased load of comorbidities pose a threat to these advancements since they are risk factors for post-AMI mechanical problems (Puerto *et al.* 2018). Although the percentage of patients presenting with STEMI has decreased over time, patients with mechanical problems today are more likely to be female, older, have a history of heart failure and chronic renal disease, and be experiencing their first acute myocardial infarction (French *et al.* 2010). Health outcomes after AMI may also be significantly impacted by socioeconomic inequalities (Rao *et al.* 2004). Medicare patients in the highest income bracket, for instance, were found to arrive at the hospital sooner, to be treated by cardiac catheterization specialists more often, and to have higher rates of guideline-directed medical therapy than patients in the lowest income bracket (Rao *et al.* 2004). There has been no change in the rate of occurrence of mechanical problems after STEMI, despite advancements in revascularization techniques and systems of care. The increasing incidence of known cardiovascular risk factors and the aging of the US population are likely contributing causes (Moreyra *et al.* 2010).

2.3 Tumor Necrosis Factor Alpha

The pleiotropic actions of the cytokine tumor necrosis factor alpha (TNF-alpha) mean that it may affect many different kinds of cells. It is known to have a role in the etiology of various inflammatory and autoimmune illnesses and has been recognized as a significant regulator of inflammatory responses (Bradley, 2008). Activated macrophages, T-lymphocytes, and natural killer cells are the primary sources of TNF-alpha (Horiuchi *et al.* 2010), which is a 157-amino-acid homotrimer protein. Its primary role is to set off a cascade of other inflammatory chemicals, such cytokines and chemokines, and this is well established. There are soluble and transmembrane forms of TNF-alpha. TNF-alpha-converting enzyme (TACE), a membrane-bound disintegrin metalloproteinase, is necessary to convert the transmembrane TNF-alpha (tmTNF-alpha), the originally generated precursor form, into the soluble TNF-alpha (sTNF-alpha) before it can be secreted (Jiang *et al.* 2017). Processing sTNF-alpha allows it to bind to and activate TNFR1, also known as TNFRSF1A, CD120a, and p55, and TNFR2, also known as TNFRSF1B, CD120b, and p75. The biological actions of tmTNF-alpha are predicted to be mediated mostly through TNFR2, however it also acts on TNFR1. TNFR1 is the primary TNF-alpha signaling receptor and is expressed in every human tissue. Widespread expression of TNFR2 in immune cells allows for specific biological responses (Morita *et al.* 2001). TNF-alpha is a cytokine that attaches to its receptors, namely TNFR1 and TNFR2, and then sends out chemical signals that regulate processes like inflammation and cell death. The death domain (DD) that interacts with the TNFR1-associated death domain (TRADD) adaptor protein is processed by TNFR1 upon activation by either sTNF-alpha or tmTNF-alpha (Pobezinskaya and Liu 2012).

2.3.1 TNF-alpha and myocardial infarction (MI)

After MI, TNF-alpha has a wide range of biological actions due to its interaction with TNFRs. TNF-alpha induces apoptosis-related protein production (including FADD and TRADD) and inflammatory factor synthesis, which in turn promotes ventricular remodeling (Kishore *et al.* 2011) when it binds to TNFR1. In a cell culture system, TNF-alpha and TNFR1 caused the production of apoptosis-related proteins that required RIP1 (receptor interacting protein 1) (Çöl-Arslan and Scheidereit 2011). This effect was reduced when TAK1 (transforming growth factor -activated kinase-1) was active. Researchers discovered that the combination of TNF-alpha and TNFR1 could activate the NF-kappaB pathway, boost endothelial cell expression of VCAM-1 and ICAM-1, increase neutrophil infiltration into the infarction area, and delay the generation of toxic substances like superoxide and perforin, all of which adversely impacted myocardial contraction and recovery from MI (Jin *et al.* 2009).

Inflammatory cytokines like IL-6 and IL-1 have their production suppressed when TNF-alpha and TNFR2 work together to activate NF-kappaB. A higher level of angiogenic growth factor expression Myocardial infarction patients who receive VEGF and bFGF had better neovascularization and survival rates. The upregulation of TNFR1 has also been linked to downregulation of TNFR2 (Kishore *et al.* 2011). The DNA damage caused by TNF-alpha and TNFR1/2 was shown to be considerably reduced by NF-kappaB inhibitors and IL-10 (Westbrook *et al.* 2012) in a variety of cell types, including T lymphocytes. Since TNF-alpha and TNFRs interact to generate reactive oxygen species (ROS), this has been hypothesized to be the mechanism of DNA damage. However, it remains unclear if this process is truly taking place in cardiomyocytes during MI.

Increased glucose uptake, better lipid metabolism, enhanced insulin sensitivity of cardiomyocytes, and protection against atherosclerosis may result from the combination of adiponectin (produced by adipocytes) and its receptor AdipoR1 (expressed on the surface of cardiomyocytes). It's possible that this combination might reduce oxidative stress, inflammation, and apoptosis in cardiomyocytes in addition to preserving and improving heart function. Adiponectin secretion is decreased during MI because both TNF-alpha and TNFR1 promote the secretion of ATF3 (activating transcription factor 3), an inhibitor of adiponectin synthesis. However, when TNF-alpha is bound to TNFR2, it promotes adiponectin secretion. As a result, the relative levels of TNF-alpha, TNFR1, and TNFR2 determine the full extent of ATF3's effect on adiponectin (Wang *et al.* 2013).

2.4 Atrial Natriuretic Peptide

Since the atria are at a prime location to detect changes in intravascular volume, atrial natriuretic peptide (ANP) is a critical regulator of sodium balance and blood pressure (Saito, 2010). Recent studies using transgenic mice have shown the role of ANP in controlling sodium excretion. Increased blood pressure and a severely diminished renal response to fluid overload were seen in ANP gene-deficient and natriuretic peptide type A receptor-knockout mice (Lopez *et al.* 1997). Extremely high plasma levels of ANP are seen in patients with illnesses characterized by impaired renal sodium excretion and manifest volume expansion, suggesting that ANP may play a crucial role as a compensatory mechanism in the case of volume overload (Sagnella 1998).

In spite of this, it has only recently been shown that ANP, BNP, and CNP all belong to the same family of homologous natriuretic peptides. These peptides are created during synthesis as large molecular weight precursors, which are then processed into their final, mature forms at the peptides' C-termini. The existence of a highly conserved S-S ring core that is 17 amino acids long is a distinguishing trait of these peptides, despite their unique sequences.

An extended form of ANP consisting of 32 amino acids has also been discovered (Hsiao *et al.* 2013). This form of ANP may be distinguished from the standard form by the presence of an additional four amino acids in the N-terminal region. This peptide, urodilatin, seems to be mostly kidney-produced as opposed to ANP. Although peptide infusion in humans produces similar natriuretic effects as infusion of ANP, urodilatin has not been found in blood and does not seem to be a component of the circulating natriuretic peptide system (Casanova *et al.* 2015).

2.4.1 Effects of the physiological levels of atrial natriuretic peptide (ANP) on inflammation and myocardial infarction (MI)

When cardiomyocytes experience ischemia due to coronary artery obstruction, they release atrial natriuretic peptide (ANP) quickly (McGrath and De-Bold, 2005). Because of its natriuretic and vasodilatory actions, ANP is crucial in maintaining normal blood pressure and volume (Federico, 2010). More recently, it was shown that guanylyl cyclase-A (GC-A), the major receptor for ANP, is expressed in immune cells and that ANP promotes inflammation. The cytotoxic effects of neutrophils are enhanced by ANP, which triggers their activation and subsequent generation of superoxide anion and degranulation (De-Vito *et al.* 2010).

Whether or whether ANP at normal concentrations affects inflammation and MI is unclear. Recently, however, ANP has been given to patients with myocardial ischemia/infarction during coronary artery reperfusion at pharmacological or supraphysiological levels. Although ANP did not affect mortality in these trials (Kitakaze *et al.* 2007), it did enhance heart function 30 days after treatment by decreasing infarct size and LV dilation and by increasing ejection fraction by a little amount. Although ANP boosted coronary collateral blood flow and decreased end-diastolic pressure, etc., in animal models, pharmaceutical dosages of ANP delivered after myocardial ischemia and reperfusion significantly decreased infarct size (Tokudome and Otani 2022).

2.5 Troponin in Acute Myocardial Infarction

In the early stages of acute MI, troponin is released. When cardiac troponin levels rise over the 99th percentile, this is considered an abnormality. When clinical myocardial ischemia is present, elevated troponin levels on at least one occasion are diagnostic of an acute MI.5 After myocardial damage occurs, elevated troponin levels may be noticed as early as 3–4 hours later (Jaffe *et al.* 2006). Elevated troponin I and troponin T serum levels may be maintained for 7–10 days and 10–14 days, respectively (Bodor 2016).

While the initial release of troponin occurs in the cytosol of cells, the continuous increase is due to troponin's sluggish diffusion from dissolving cardiac myofilaments (Mueller *et al.* 2013). Because of these mechanisms, the sensitivity of troponin increases with time. After 6 or more hours have elapsed from the commencement of myocardial necrosis, troponin detection is 99% sensitive (Jaffe *et al.* 2006). This means that 60 minutes after the onset of acute MI, the sensitivity is only about 90%. To improve clinical sensitivity for ruling in acute MI and specificity for ruling out acute MI, blood samples for evaluating troponin levels should be collected at presentation and 6-9 hours later (Lenicek-Krleza *et al.* 2015).

After 12 hours in the hospital, serial testing of cardiac troponins has a sensitivity of around 95% and a specificity of about 90% (Mann *et al.* 2014). Due to its strong tissue specificity, cardiac troponin is less likely to provide false-positive results in the context of concomitant skeletal muscle injury as compared to CK-MB. Evaluation of myocardial damage using troponin may be helpful for patients with chronic muscle problems, perioperative MIs, and those recovering from electrical cardioversion or acute cardiac trauma (Adams *et al.* 1994). Though cardiac troponin is very specific to its tissue of origin, an elevated level does not always indicate the mechanism of myocardial damage; if elevated troponins are seen in the absence of myocardial ischemia, other alternative sources of myocardial injury should be explored.

High-sensitivity cardiac troponin tests, which may detect extremely low quantities of cardiac troponins owing to modifications in how the assays are conducted, have been developed and are still under active development in recent years. Patients with acute MI frequently have abnormal high-sensitivity troponins sooner than normal troponins. High-sensitivity troponins have this quality, allowing them to be used to rule out individuals with suspected ACS more rapidly and safely than with traditional troponins (Cullen *et al.* 2013). Acute versus chronic causes of high-sensitivity troponin elevations are difficult to distinguish, and the optimal duration of the rule-out period for acute MI is unclear. These factors have prevented the widespread implementation of this assay (Korley and Jaffe 2013).

Because conventional troponin assays do not reliably permit the very early (initial 1 to 2 hours) detection of myocardial necrosis, the diagnosis of acute MI in patients presenting within 6 hours of symptom onset must be based on the clinical scenario, ECG findings, and adjunctive imaging techniques. Biomarkers verifying myocardial injury are not necessary before treating individuals with STEMI with reperfusion therapy (Mehta *et al.* 2005).

Elevated troponins are not only essential for the diagnosis of NSTEMI but also for treatment, as they may be used to identify patients who may benefit from an early invasive management approach. The Treat Angina with Aggrastat and Determine Cost of Therapy with an Invasive or Conservative Strategy-Thrombolysis in Myocardial Infarction 18 (TACTICS-TIMI 18) study found that patients with any increase in troponin who underwent early angiography (within 4 to 48 hours) and revascularization (if appropriate) had approximately 55% lower odds of death or MI compared with patients under conservative management (Wong *et al.* 2002).

2.6 Humans C-reactive protein (CRP)

C-reactive protein (CRP) is a prominent acute phase protein in humans, with concentrations increasing by as much as 1,000-fold under very inflammatory conditions. Five identical, non-covalently bonded subunits of 206 amino acid residues (or around 23 kDa) make up human CRP, making it a pentameric protein. Ca2+ is required for the binding of human CRP to PCh. Each of the five subunits has one PCh-binding site. Devaraj *et al.* (2009) found that each subunit could bind two Ca2+ ions. Glu81 in human CRP's PCh-binding site interacts with the PCh molecule's nitrogen atom, Phe66 with PCh's three methyl groups, and Thr76, critically, with making the pocket large enough to hold PCh. PCh's phosphate group forms a direct coordination pair with CRP's two Ca2+ ions. Direct Ca2+ binding to a CRP-derived synthetic peptide spanning residues 134-148 has been shown. Two Ca2+ ions are coordinated in a loop by residues Asp60, Asn61, Glu138, Gln139, Asp140, Glu147, and Gln150, as shown by crystallography of CRP (Mikolajek *et al.* 2011). When CRP binds to a PCh-containing ligand, the conventional complement pathway is initiated. The development of the C1q-binding site in CRP is dependent on the contributions of residues Asp112 and Tyr175 (Ngwa *et al.* 2022).

For CRP to bind to immobilized, denatured, and aggregated proteins, it must undergo a conformational change from its native pentameric state into a different pentameric shape termed non-native CRP when exposed to an acidic pH. It has been shown that CRP loses its capacity to bind to oxidized LDL (ox-LDL) at physiological pH but acquires it at acidic pH (Zeller *et al.* 2023) as an example. Like acidic pH, H2O2 is a modulator of the structure and ligand recognition function of CRP, since it confers a ligand recognition feature on H2O2-treated CRP that is absent in native CRP. Binding to immobilized, denatured, and aggregated proteins may also be achieved by immobilizing CRP or by mutation of Glu42 in the inter-subunit interaction area in pentameric CRP (Agrawal *et al.* 2014). The solitary inherently disordered region of CRP may serve as a binding site in non-native CRP for immobilized, denatured, and aggregated proteins. It has been established that when CRP dissociates into its monomers, the inherently disordered area of monomeric CRP serves as a receptor for these protein ligands (Li *et al.* 2016).

Glycosylation sites are present in human CRP, although they are not readily apparent in native CRP (Jasensky *et al.* 2014). C-reactive protein (CRP) was discovered to be differently glycosylated when extracted from individuals with six distinct clinical diseases. Glycosylated human CRP is lacking a few amino acids at the N-terminus and a few amino acids at the C-terminus. Two putative sites of glycosylation, positioned on the face of CRP opposite the PCh-binding face, are exposed when these peptides are cleaved off CRP. Glycosylated C-reactive protein (CRP) may have a preventive effect in illnesses by facilitating the removal of damaged erythrocytes (Pathak and Agrawal 2019).

2.6.1 C-reactive protein and acute myocardial infarction

The inflammatory marker high-sensitivity C-reactive protein (hs-CRP) is one of numerous circulating biomarkers for atherosclerotic inflammation, and it has been the subject of much research for use in cardiovascular risk stratification (Shrivastava *et al.* 2015). In the early stages of acute myocardial infarction (Suleiman *et al.* 2006), a sharp increase in hs-CRP is caused by an initial inflammatory response triggered by myocardial necrosis superimposed on preexisting atherosclerotic inflammation. An elevated hs-CRP following AMI has been shown to be an independent predictor of both short- and long-term adverse cardiovascular outcomes (He *et al.* 2010). Although hs-CRP levels are typically reduced over the subsequent several weeks after AMI, particularly in patients undergoing successful percutaneous coronary intervention (PCI), the duration of the prognostic effect for predicting future adverse outcome by baseline hs-CRP has not been clearly defined (Sánchez *et al.* 2006).

The use of statins has been shown to reduce cardiovascular risk in a variety of people (Baigent *et al.* 2010). Independent of its lipid-lowering effects, statin's anti-inflammatory activity has a significant impact in decreasing cardiovascular risk (Mihos *et al.* 2014). High-intensity statin usage is advised for secondary prevention after AMI, and it is well established that lowering hs-CRP levels with statin medication leads to considerable improvements in clinical outcomes (Kawada-Watanabe *et al.* 2020). The use of statins is associated with lower levels of hs-CRP, and a greater drop in levels is anticipated with the use of higher intensity medication (Kang *et al.* 2019). It is uncertain if the use of high-intensity statin may make a further impact on the prognostic effects of baseline hs-CRP, but it is obvious that the larger anti-inflammatory activity produced by higher intensity statin therapy has a considerable influence in improving prognosis after AMI. Furthermore, the predictive impact of baseline hs-CRP is no longer apparent, and it is unclear if the therapeutic benefit of high-intensity statin therapy continues to be consistent.

2.7 Creatine Kinase

Skeletal muscle, heart, and the brain have the highest concentrations of the intracellular enzyme creatine kinase (CK), originally known as creatine phosphokinase (Vishawanath *et al.* 2023).

When cell membranes are damaged, whether by hypoxia or injury, CK is released from the cytosol and circulates throughout the body. This fact has led to the adoption of CK serum levels as a sensitive but generic indicator of myocardial infarction. Due of CK's widespread presence in tissues outside the heart, its specificity is low.

There is no universally accepted reference value for serum CK since there are so many different test techniques currently in use. Using the approach used and the ranges for healthy controls, normal values are best established at the regional level. International units per liter are used to represent the values (Kazak and Cohen 2020).

The two subunits of CK, M and B, form a dimeric molecule. The isoenzymes CK-MM, CK-MB, and CK-BB are all composed of different combinations of these subunits. Myocardial cells have a high quantity of the CK-MB isoenzyme, and the detection of increased CK-MB levels in blood is a highly specific and sensitive indicator of myocardial cell wall damage. Serum CK-MB levels should typically hover around 3–5% (as a proportion of total CK) or 5–25 IU/L (Fraga *et al.* 2022).

2.8 Lactate Dehydrogenase

One of the most crucial enzymes in the anaerobic metabolic pathway is called lactate dehydrogenase (LDH). It is categorized as an oxidoreductase. This enzyme reduces NAD+ to NADH, allowing lactate to be converted into pyruvate, and vice versa (Farhana and Lappin 2022). The enzyme may be found in a wide range of plant and animal species. It is found in every organ and plays a critical role in regulating DNA synthesis and gluconeogenesis. The amino acid sequence of LDH is highly conserved, showing just a few variations across species (Ghaffari *et al.* 2022). Modifying the enzyme's catalytic potential and expression is made easier by the fact that identical structures may be derived from a small number of different amino acids. The LDH enzyme's biochemical role, diagnostic procedures, and clinical significance will be discussed in this article.

2.9 Obesity and Acute Myocardial Infarction

The incidence of obesity is rising not only among adults but also among young people (Shiraishi *et al.* 2006), and it is now recognized that adult obesity is a risk factor for coronary heart disease (CHD) (Zhu *et al.* 2014). Recent research has linked obesity with coronary atherosclerosis in young male adults, especially those with a central pattern of adiposity, but found minimal link between the two in young female individuals (Wang *et al.* 2016). Another recent study (Marinou *et al.* 2010) links obesity and its underlying metabolic abnormalities (i.e., metabolic syndrome) to an early atherosclerotic change in adolescents. Although our recent work showed that younger patients with AMI had a greater BMI compared to older patients6, it is still unclear whether or whether obesity is a risk factor for CHD Circulation in young individuals.

3. MATERIALS AND METHODS

3.1 Design of Study

In the emergency rooms and coronary care units of multiple Baghdad hospitals, 80 consecutive patients with AMI were evaluated. Prolonged chest pain, serial changes on a standard 12-lead electrocardiogram, and an elevated serum creatine kinase (CK) level (greater than twice the upper limit of normal value measured in a biochemical laboratory) were all used as diagnostic hallmarks for acute myocardial infarction. Aspirin (200 mg/day) was the only anti-inflammatory medication used by any of the patients. There were 80 healthy volunteers in the control group.

The study was divided into two groups:

- ❖ Group A: 80 with myocardial infarction (Patient group)
- ❖ Group B: 80 without myocardial infarction (Control group)

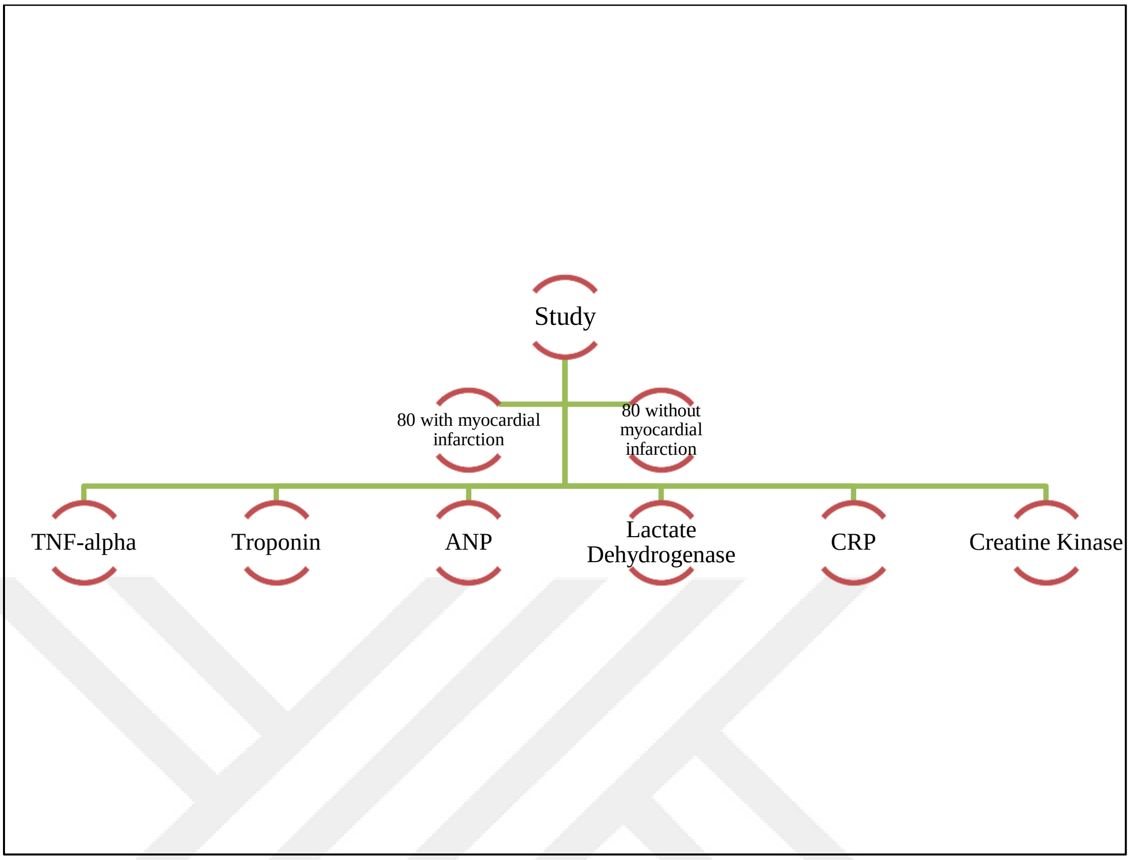

Figure 3.1 Scheme of the study plan

3.2 Excluded Samples

Patients or controls in the present research did not have to be free of neoplastic illness, infection, autoimmune disease, or a recent surgical treatment. Those who had recently had a myocardial infarction and were getting treatment were not included.

3.3 Sample Collection

Patients with myocardial infarction had 5 ml of blood extracted from a vein, put in a gel tube, and centrifuged at 3500 rpm for 6 minutes to gather samples from various areas of Baghdad, Iraq. After that, 3 Eppendorf tubes were filled with the serum that had been extracted. The gel tubes were smashed to pieces thereafter. The Eppendorf tubes were then chilled to -20 degrees Celsius in a refrigerator.

3.4 Martial

3.4.1 Devices and tools

Origin had all the necessary gadgets and tools for this investigation. Table 2.1 shows the results.

Table 3.1 Lest of devices and tools used

NO.	Devices And Instruments	Origin
1	1 mL pipette tips	china
2	Pipette Tips	china
3	Autoclave	Japan
4	Micropipettes (100-1000µL), (5-50µL), (20-200µL), (2-20µL)	Slamed / Germany
5	ELISA reader	Biotech /USA
6	Spectrometer	Varian/Austria
7	Incubator	Fisher Scient./Germany
8	ELISA washer	Biotech /USA
9	Deep Freeze	Germany
10	Water bath	GFL / Germany
11	Pipette Tips Yellow	china
12	Distiller	Germany
13	Cobas C111	Germany
14	Gel Tubes	china
15	Eppendorf tube (1.5mL)	china
16	0.01 mL pipette tips	china
17	Pipette Tips Blue	China
18	Centrifuge	Germany

3.5 Methods

3.5.1 Human TNF-alpha (tumor necrosis factor alpha) ELISA kit

Catalog No: MBS2502004

Specification:

- Sensitivity: 4.69pg/mL.
- Detection Range: 7.81-500pg/mL
- Specificity: Human TNF-alpha may be detected using this kit. Human TNF-alpha showed no evidence of cross-reactivity or interaction with analogues.
- Repeatability: Coefficient of variation

Test principle: This ELISA kit is based on the sandwich ELISA method. The Human TNF-alpha antibody is pre-coated on a micro ELISA plate included in this kit. Micro ELISA plates include wells for combining standards or samples with the appropriate antibody. After incubating the microplate wells with a biotinylated detection antibody specific for Human TNF-alpha, we use an Avidin-Horseradish Peroxidase (HRP) combination. All the loose stuff is flushed down the drain. The substrate solution is individually dispensed into each well. The blue staining in the wells is achieved with the addition of human tumor necrosis factor alpha, a biotinylated detection antibody, and an Avidin-HRP conjugate. When the enzyme-substrate reaction is stopped by adding the stop solution, the color becomes yellow. The optical density (OD) is measured at a wavelength of 450 nm 2 nm using spectrophotometry. Optical density is associated with the levels of human tumor necrosis factor alpha. The concentration of Human TNF-alpha in samples may be calculated by plotting their optical densities (ODs) against those of the standard curve.

3.5.2 Human atrial natriuretic peptide (ANP) ELISA kit

Cat No. MBS264010

- Detection range: 1000 pg/mL-15.6 pg/mL
- Sensitivity: The minimum detectable Human ANP up to 5 pg/mL.
- Recovery: 70 - 110 percent.
- Specifications: 96T.

Test principle: As was mentioned before, this kit uses the Double Antibody Sandwich ELISA technique. In contrast to the anti-Human ANP monoclonal antibody used for capture, which is biotinylated, the polyclonal antibody used for capture is biotinylated. Wells in an ELISA plate allow for the addition of samples and biotinylated antibodies before being cleaned in PBS or TBS. Avidin-peroxidase conjugates are then added to the wells. TMB substrate is used to dye the wells after PBS or TBS has been used to remove the enzyme conjugate. TMB reacts as a consequence of peroxidase activity, creating a blue product that is converted to yellow by the addition of a stop solution (Color Reagent C). The concentration of the analyte of interest correlates positively with the intensity of the color.

3.5.3 Cobas CRP test

The premise of the test involves centrifuging a sample of capillary or venous blood to separate the erythrocytes from the plasma. The plasma sample is then diluted with HEPES buffer before being added to a reaction chamber containing CRP antibody latex reagent. Diluted plasma containing CRP binds to a latex particle coated with an antibody specific to CRP. CRP concentration is determined by measuring the degree of agglutination, which is proportional to the change in absorbance at 525 nm and 625 nm.

3.5.4 Roche troponin T

The Roche CARDIAC POC Troponin T test works on the basis of two monoclonal antibodies, one gold-labelled and the other biotinylated, that recognize cardiac troponin T (cTnT). Antibodies in the blood combine with cTnT to create a sandwich-like complex. After erythrocytes are removed and the plasma flows through the detecting zone where the gold-labelled cTnT sandwich complexes gather, a positive signal is detected as a red line (the signal line) in the assay. Assay validity is shown by the accumulation of gold-labeled antibodies in the control line. As troponin T levels rise, so does the strength of the signal line. The instrument's optical system picks up on the presence of both lines, and the signal line's strength is then quantified. The inbuilt software takes the raw signal strength and displays a numerical value.

Calculation: Each sample's concentration is determined mechanically by the equipment. The Roche CARDIAC POC Troponin T test provides a quantitative reading after a response time of 12 minutes. Furthermore, sample detection takes around 2 minutes.

3.5.5 Roche aspartate aminotransferase

Cat No. 20764949322

The principle: Procedure following the IFCC guidelines, excluding the use of pyridoxal-5-phosphate. L-aspartate and 2-oxoglutarate undergo amino group transfer catalyzed by AST in the sample, resulting in oxaloacetate and L-glutamate. In the presence of malate dehydrogenase (MDH), the oxaloacetate interacts with NADH to produce NAD+.

3.6 Statistical Analysis

Data analysis was performed using SPSS26.0 software. The Excel program was used to draw the curves of the parameters of this study. Spearman or Pearson tests were used to perform correlation analyses. Measurement data are expressed as (x ± s), and t-tests were used for comparisons between groups. Stepwise logistic regression analysis was performed to examine the relevant parameters and independent risk factors. Differences with the P value.

4. RESULTS AND DISCUSSION

4.1 Descriptive Data

In Table 4.1 the age and BMI of myocardial infraction patients and controls are listed in values of mean and standard deviation for total subjects, and males and females separately.

Table 4.1 Age and BMI of myocardial patients and controls

VARIABLES	CONTROL	MYOCARDIAL INFRACTION PATIENTS	P-VALUE
		Age	
Total	43.81±9.34	45.51±10.89	0.291
Male	43.08±9.20	45.03±10.80	0.387
Female	44.55±9.53	46.00±11.09	0.532
		BMI (kg/m^2)	
Total	24.77±2.53	24.86±2.30	0.814
Male	24.79±2.59	24.99±2.14	0.703
Female	24.75±2.50	24.73±2.47	0.967

As shown in Table 4.1, the age of the total subjects (males and females) was non-significantly ($P>0.05$) different in myocardial infraction patients (45.51±10.89 year) compared to controls (43.81±9.34 year), which is graphically demonstrated in Figure 4.1.

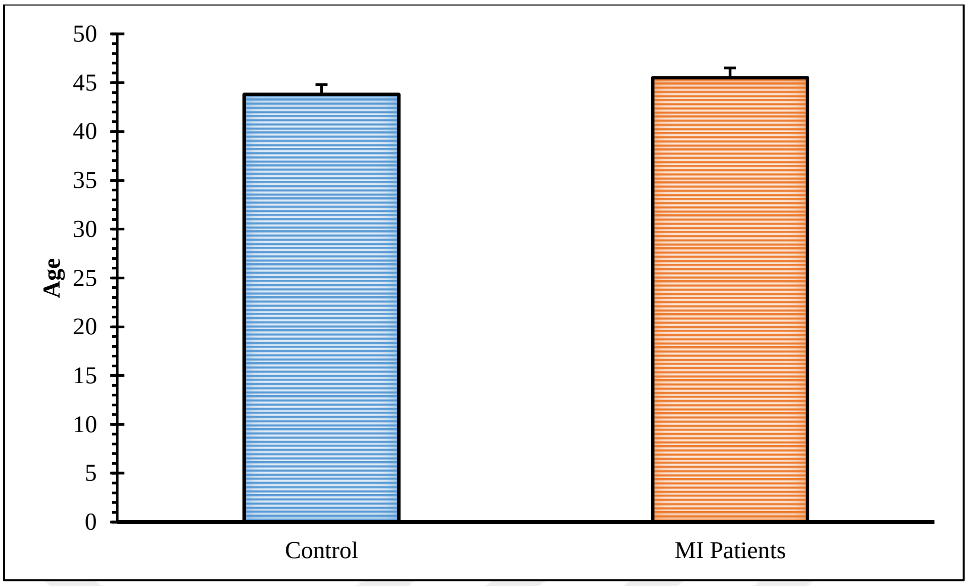

Figure 4.1 Graphic presentation of age comparison between myocardial infraction patients and controls

As shown in Table 4.1, the age of the male subjects was non-significantly (P>0.05) different in myocardial infraction patients (45.03±10.80 year) compared to controls (43.08±9.20 year), which is graphically demonstrated in Figure 4.2.

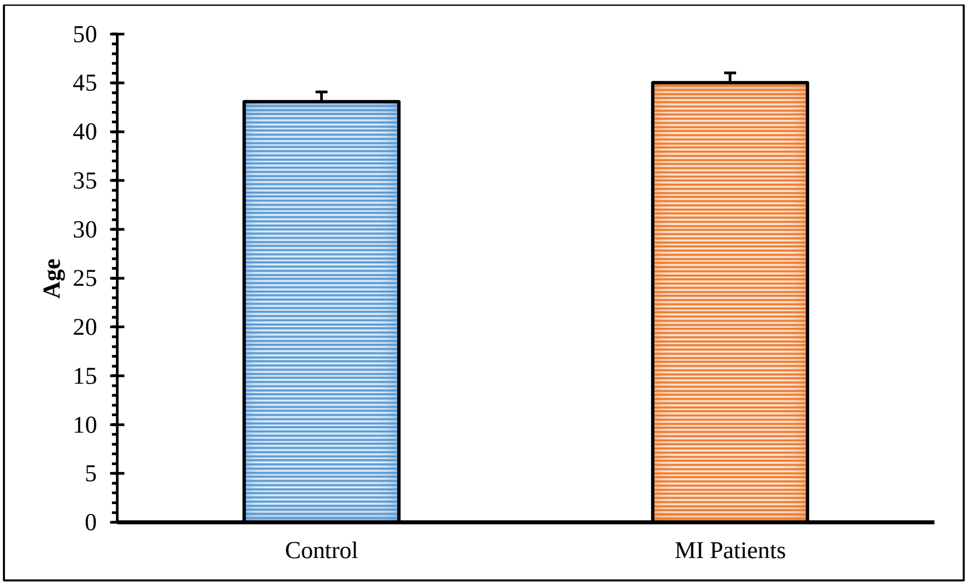

Figure 4.2 Graphic presentation of age comparison between male myocardial infraction patients and male controls

As shown in Table 4.1, the age of the female subjects was non-significantly (P>0.05) different in myocardial infraction patients (46.00±11.09 year) compared to controls (44.55±9.53 year), which is graphically demonstrated in Figure 4.3.

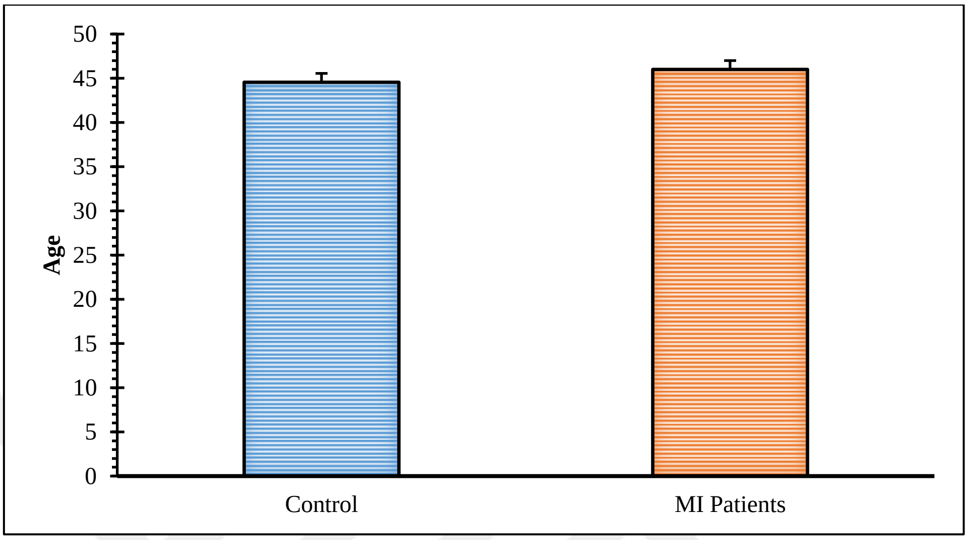

Figure 4.3 Graphic presentation of age comparison between female myocardial infraction patients and female controls

As shown in Table 4.1, the BMI of the total subjects (males and females) was non-significantly (P>0.05) different in myocardial infraction patients (24.86±2.30 kg/m^2) compared to controls (24.77±2.53 kg/m^2), which is graphically showed in Figure 4.4.

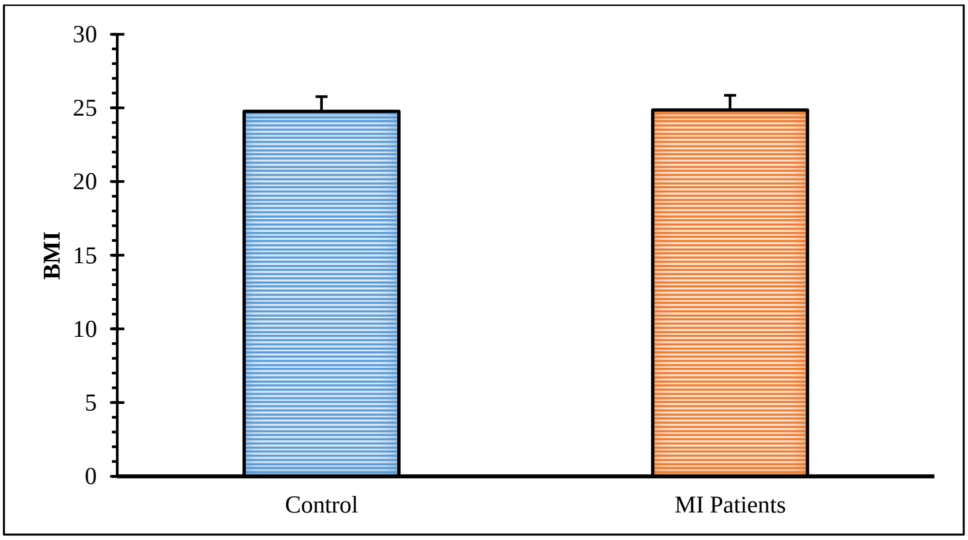

Figure 4.4 Graphic presentation of BMI comparison between myocardial infraction patients and controls

As shown in Table 4.1, the BMI of the male subjects was non-significantly (P>0.05) different in myocardial infraction patients (24.99±2.14 kg/m^2) compared to controls (24.79±2.59 kg/m^2), which is graphically demonstrated in Figure 4.5.

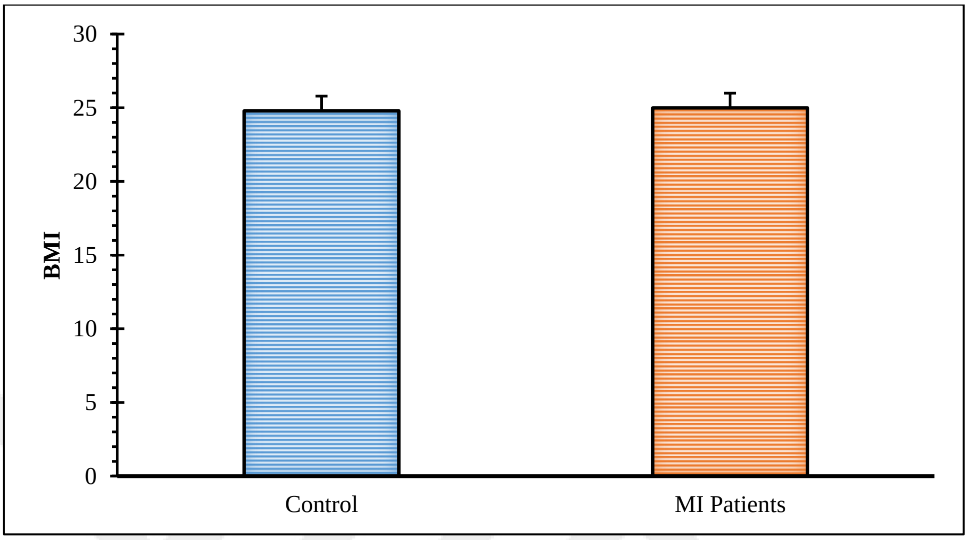

Figure 4.5 Graphic presentation of BMI comparison between male myocardial infraction patients and male controls

As shown in Table 4.1, the BMI of the female subjects was non-significantly (P>0.05) different in myocardial infraction patients (24.73±2.47 kg/m^2) compared to controls (24.75±2.50 kg/m^2), which is graphically demonstrated in Figure 4.6.

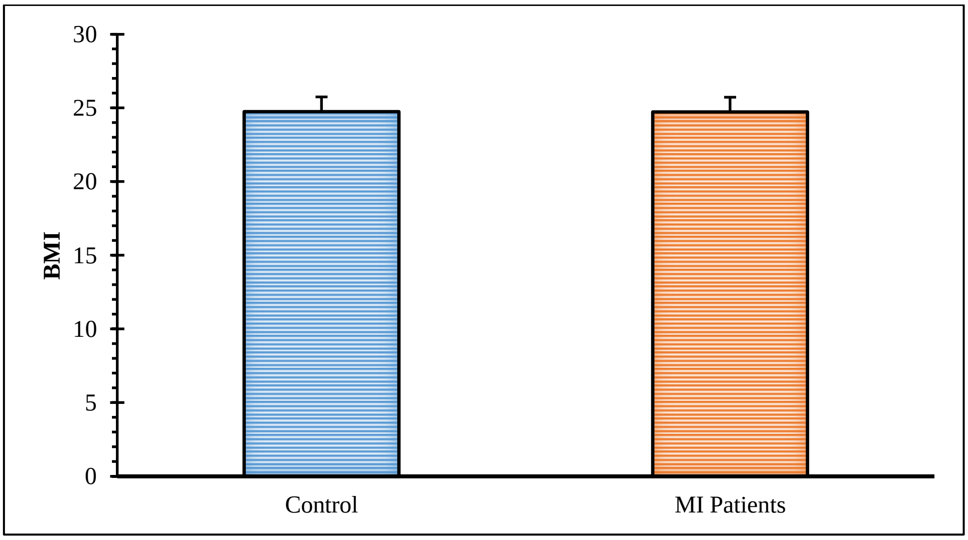

Figure 4.6 Graphic presentation of BMI comparison between female myocardial infraction patients and female controls

4.2 C-Reactive Protein

In Table 4.2 the CRP levels of myocardial infraction patients and controls are listed in values of mean and standard deviation for total subjects, and males and females separately.

Table 4.2 CRP level in myocardial patients and controls

VARIABLES	CONTROL	MYOCARDIAL INFRACTION PATIENTS	P-VALUE
		CRP (mg/L)	
Total	7.11±2.30	15.90±9.75	<0.001
Male	7.53±2.35	11.70±5.83	<0.001
Female	6.70±2.19	19.84±11.26	<0.001

As shown in Table 4.2, the CRP level of the total subjects (males and females) was significantly (P<0.05) different (higher) in myocardial infraction patients (15.90±9.75 mg/L) compared to controls (7.11±2.30 mg/L), which is graphically demonstrated in Figure 4.7.

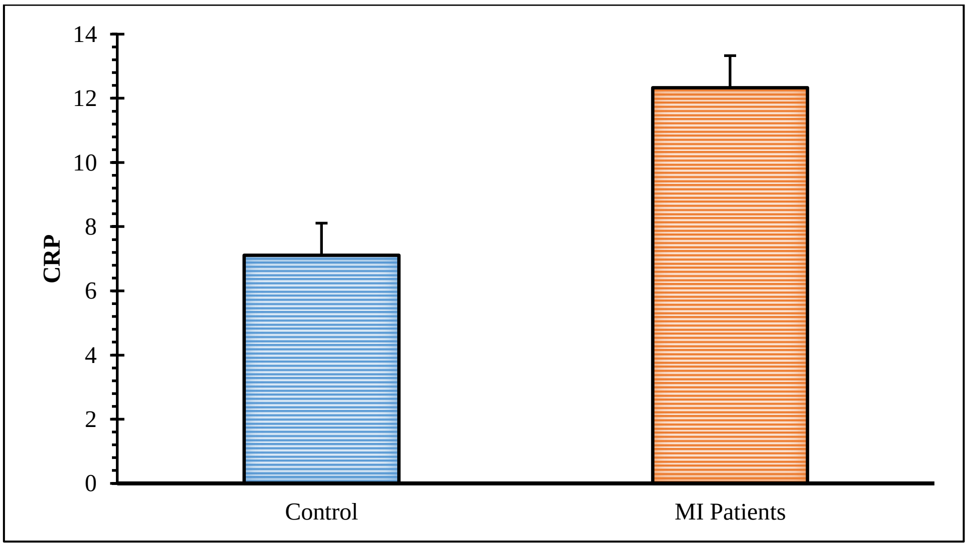

Figure 4.7 Graphic presentation of CRP comparison between myocardial infraction patients and controls

As shown in Table 4.2, the CRP level of the male subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (11.70±5.83 mg/L) compared to controls (7.53±2.35 mg/L), which is graphically demonstrated in Figure 4.8.

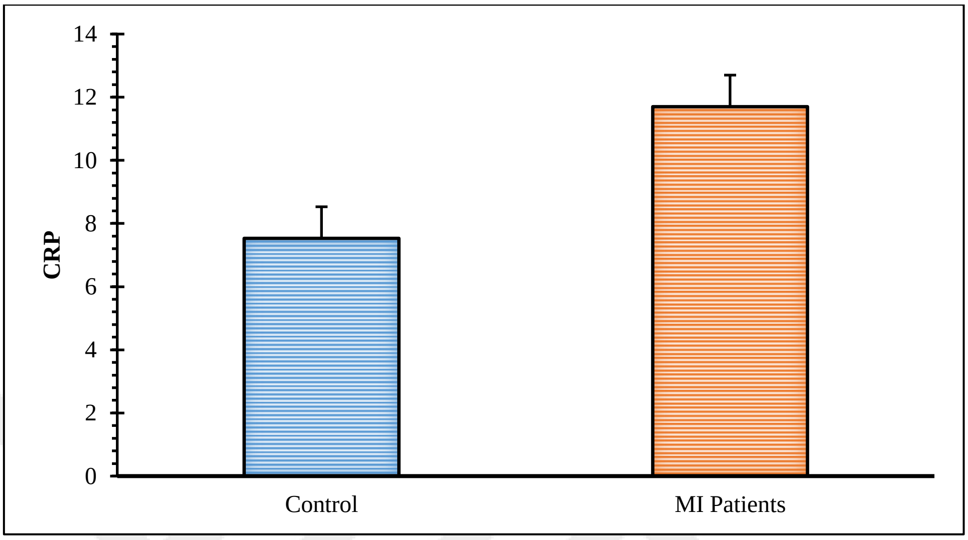

Figure 4.8 Graphic presentation of CRP comparison between male myocardial infraction patients and male controls

As shown in Table 4.2, the CRP level of the female subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (19.84±11.26 mg/L) compared to controls (6.70±2.19 mg/L), which is graphically demonstrated in Figure 4.9.

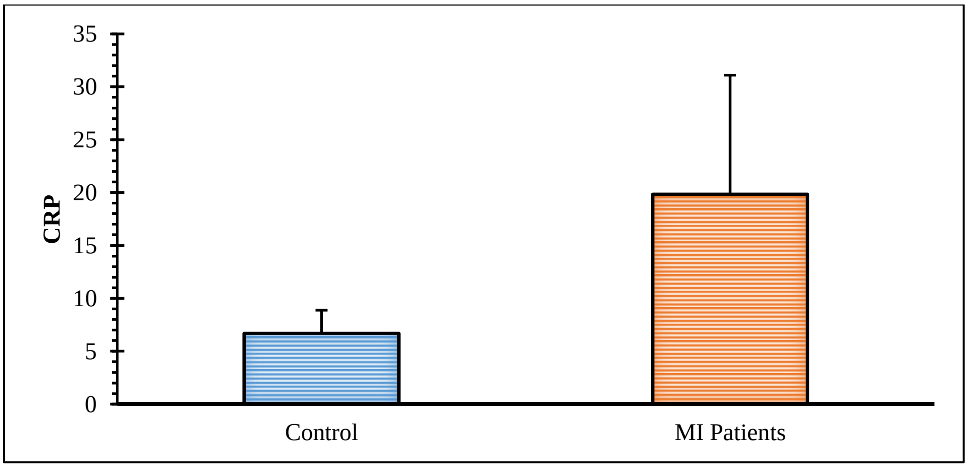

Figure 4.9 Graphic presentation of CRP comparison between female myocardial infraction patients and female controls

4.3 Troponin t

In Table 4.3 the troponin t levels of myocardial infraction patients and controls are listed in values of mean and standard deviation for total subjects, and males and females separately.

Table 4.3 troponin t level in myocardial patients and controls

VARIABLES	CONTROL	MYOCARDIAL INFRACTION PATIENTS	P-VALUE
		Troponin t (ng/L)	
Total	6.23±2.74	79.40±21.61	<0.001
Male	6.98±3.11	84.08±23.59	<0.001
Female	5.49±2.10	74.73±18.57	<0.001

As shown in Table 4.3, the troponin level of the total subjects (males and females) was significantly ($P<0.05$) different (higher) in myocardial infraction patients (79.40±21.61 ng/L) compared to controls (6.23±2.74 ng/L), which is graphically demonstrated in Figure 4.10.

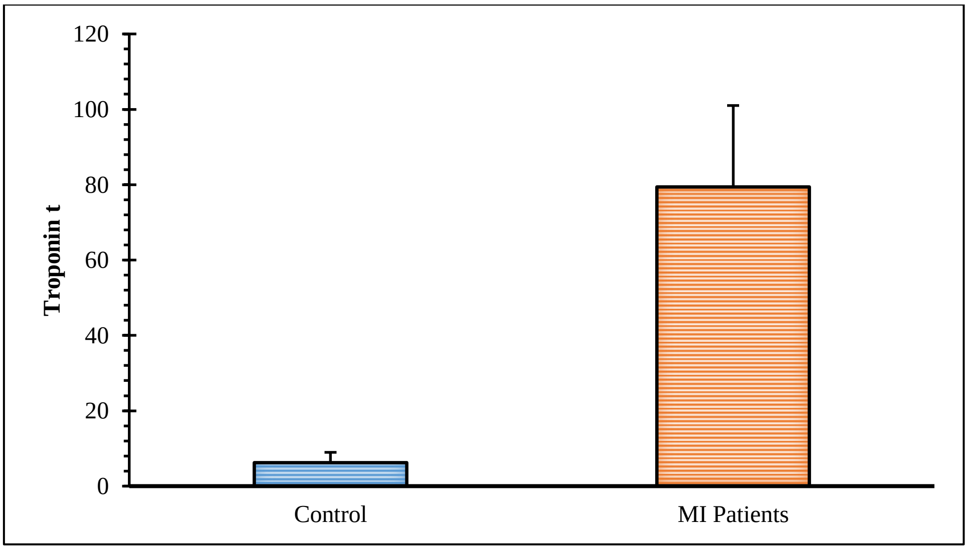

Figure 4.10 Graphic presentation of troponin t comparison between myocardial infraction patients and controls

As shown in Table 4.3, the troponin level of the male subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (84.08±23.59 ng/L) compared to controls (6.98±3.11 ng/L), which is graphically shown in Figure 4.11.

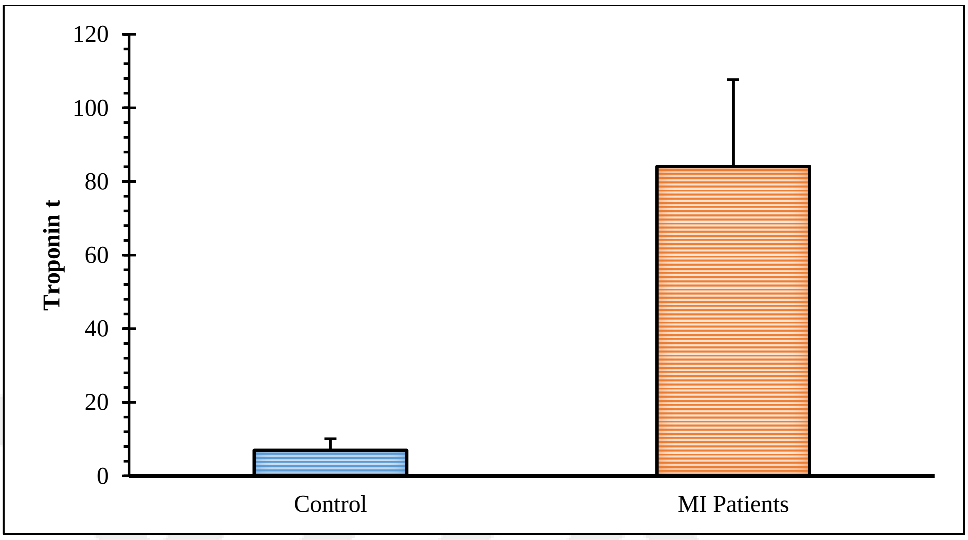

Figure 4.11 Graphic presentation of troponin t comparison between male myocardial infraction patients and male controls

As shown in Table 4.3, the troponin level of the female subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (74.73±18.57 ng/L) compared to controls (5.49±2.10 ng/L), which is graphically shown in Figure 4.12.

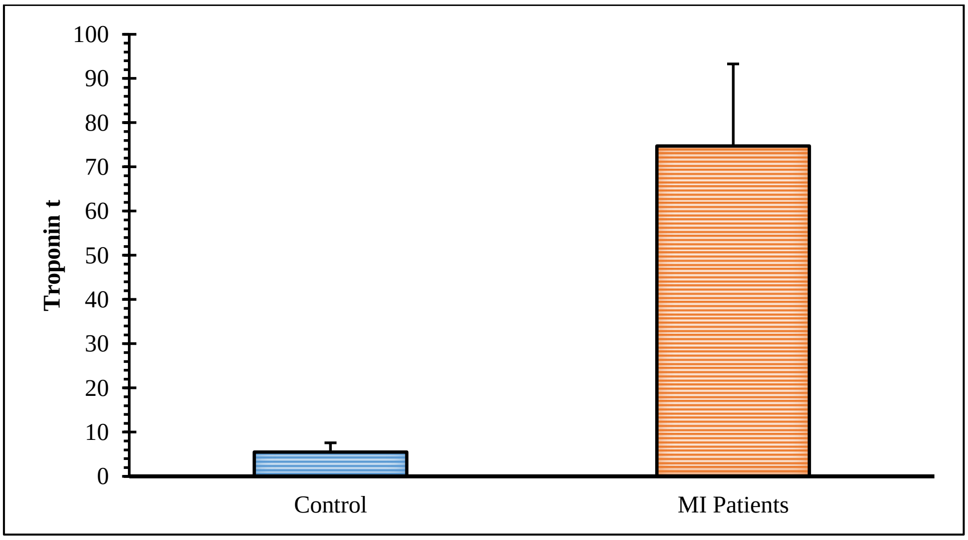

Figure 4.12 Graphic presentation of troponin t comparison between female myocardial infraction patients and female controls

4.4 Tumor Necrosis Factor Alpha

In Table 4.4 the TNFalpha levels of myocardial infraction patients and controls are listed in values of mean and standard deviation for total subjects, and males and females separately.

Table 4.4 TNFalpha level in myocardial patients and controls

VARIABLES	CONTROL	MYOCARDIAL INFRACTION PATIENTS	P-VALUE
		TNFalpha (pg/mL)	
Total	78.53±32.30	253.95±119.48	<0.001
Male	79.22±34.61	236.24±111.23	<0.001
Female	77.83±30.24	271.67±126.10	<0.001

As shown in Table 4.4, the TNFalpha level of the total subjects (males and females) was significantly ($P<0.05$) different (higher) in myocardial infraction patients (253.95±119.48 pg/mL) compared to controls (78.53±32.30 pg/mL), which is graphically demonstrated in Figure 4.13.

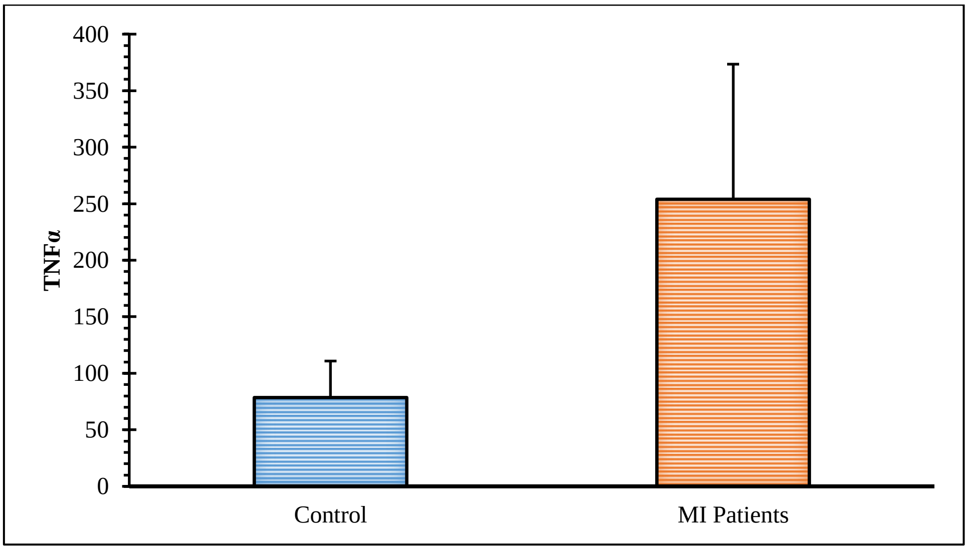

Figure 4.13 Graphic presentation of TNFalpha comparison between myocardial infraction patients and controls

As shown in Table 4.4, the TNFalpha level of the male subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (236.24±111.23 pg/mL) compared to controls (79.22±34.61 pg/mL), which is graphically demonstrated in Figure 4.14.

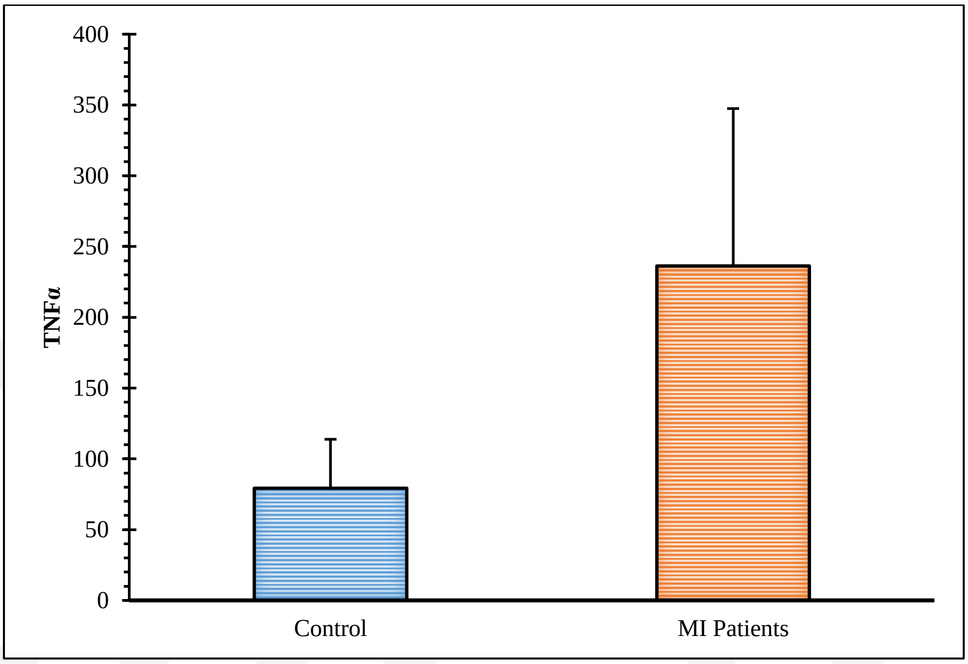

Figure 4.14 Graphic presentation of TNFalpha comparison between male myocardial infraction patients and male controls

As shown in Table 4.4, the TNFalpha level of the female subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (271.67±126.10 pg/mL) compared to controls (77.83±30.24 pg/mL), which is graphically demonstrated in Figure 4.15.

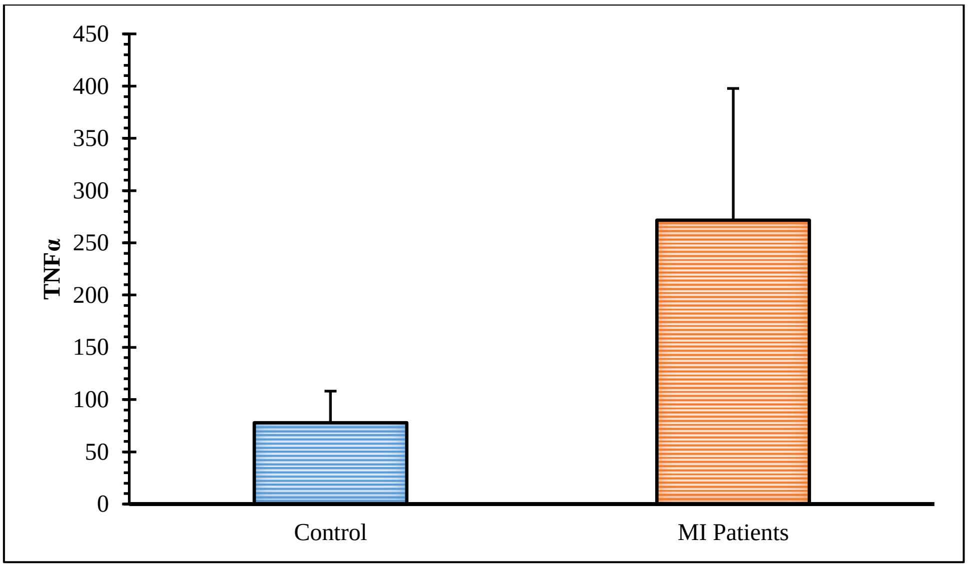

Figure 4.15 Graphic presentation of TNFalpha comparison between female myocardial infraction patients and female controls

4.5 Arterial Natriuretic Peptide

In Table 4.5 the ANP levels of myocardial infraction patients and controls are listed in values of mean and standard deviation for total subjects, and males and females separately.

Table 4.5 ANP level in myocardial patients and controls

VARIABLES	CONTROL	MYOCARDIAL INFRACTION PATIENTS	P-VALUE
		ANP (pg/mL)	
Total	4.38±3.10	6.18±5.30	0.010
Male	4.40±2.76	6.67±5.68	0.026
Female	4.36±3.44	5.70±4.91	0.162

As shown in Table 4.5, the ANP level of the total subjects (males and females) was significantly ($P<0.05$) different (higher) in myocardial infraction patients (6.18±5.30

pg/mL) compared to controls (4.38±3.10 pg/mL), which is graphically demonstrated in Figure 4.16.

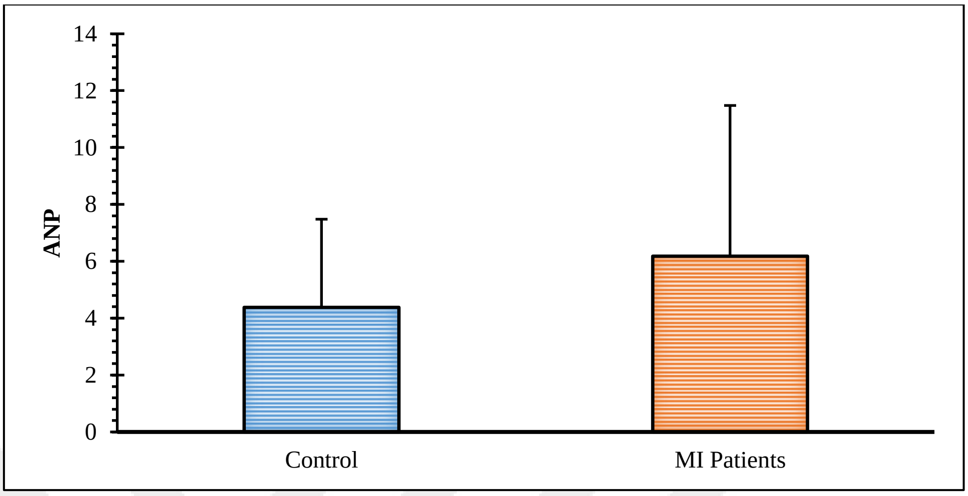

Figure 4.16 Graphic presentation of ANP comparison between myocardial infraction patients and controls

As shown in Table 4.5, the ANP level of the male subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (6.67±5.68 pg/mL) compared to controls (4.40±2.76 pg/mL), which is graphically demonstrated in Figure 4.17.

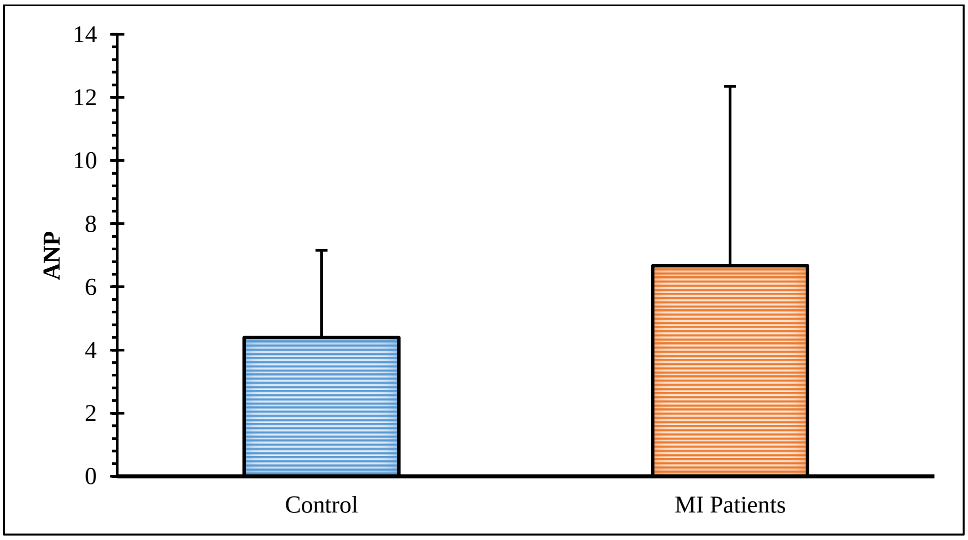

Figure 4.17 Graphic presentation of ANP comparison between male myocardial infraction patients and male controls

As shown in Table 4.5, the ANP level of the male subjects was non-significantly (P>0.05) different in myocardial infraction patients (5.70±4.91 pg/mL) compared to controls (4.36±3.44 pg/mL), which is graphically demonstrated in Figure 4.18.

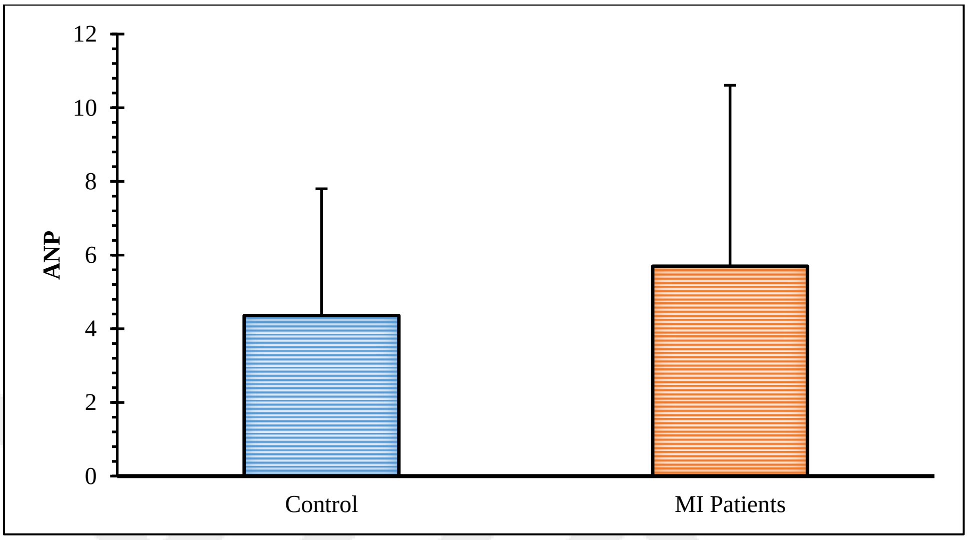

Figure 4.18 Graphic presentation of ANP comparison between female myocardial infraction patients and female controls

4.6 Creatine Kinase

In Table 4.6 the CK activity of myocardial infraction patients and controls are listed in values of mean and standard deviation for total subjects, and males and females separately.

Table 4.6 CK activity in myocardial patients and controls

VARIABLES	CONTROL	MYOCARDIAL INFRACTION PATIENTS	P-VALUE
		CK (U/L)	
Total	87.70±25.45	407.89±108.79	<0.001
Male	94.99±24.08	397.26±99.24	<0.001
Female	80.40±24.97	418.51±117.87	<0.001

As shown in Table 4.6, the CK activity of the total subjects (males and females) was significantly ($P<0.05$) different (higher) in myocardial infraction patients (407.89±108.79 U/L) compared to controls (87.70±25.45 U/L), which is graphically demonstrated in Figure 4.19.

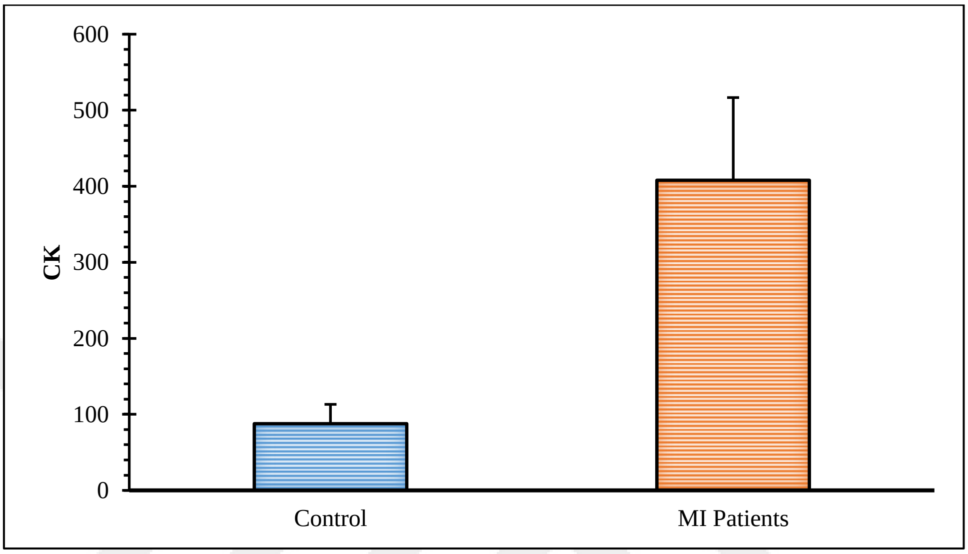

Figure 4.19 Graphic presentation of CK comparison between myocardial infraction patients and controls

As shown in Table 4.6, the CK activity of the male subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (397.26±99.24 U/L) compared to controls (94.99±24.08 U/L), which is graphically demonstrated in Figure 4.20.

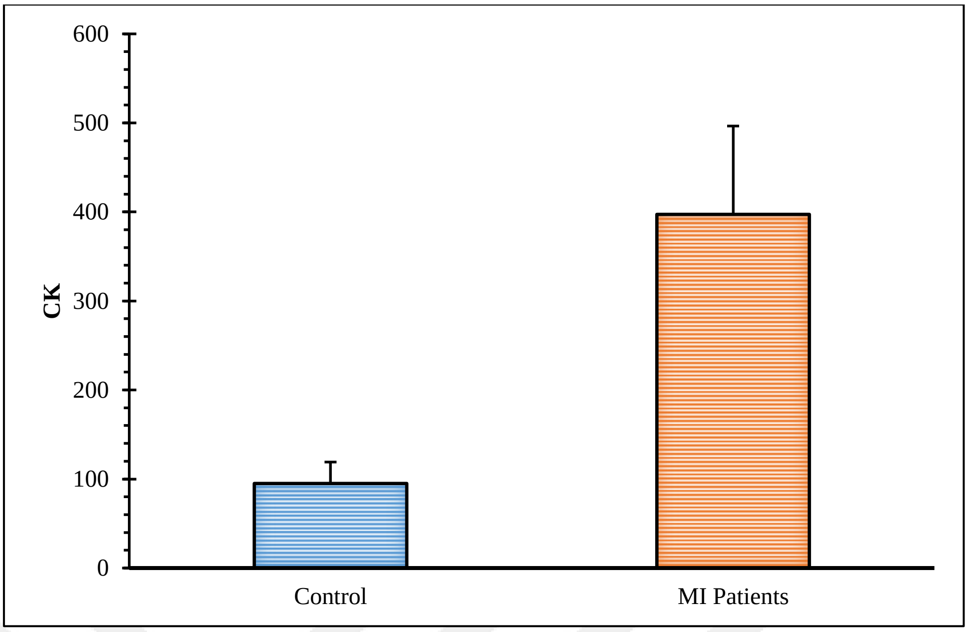

Figure 4.20 Graphic presentation of CK comparison between male myocardial infraction patients and male controls

As shown in Table 4.6, the CK activity of the male subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (418.51±117.87 U/L) compared to controls (80.40±24.97 U/L), which is graphically demonstrated in Figure 4.21.

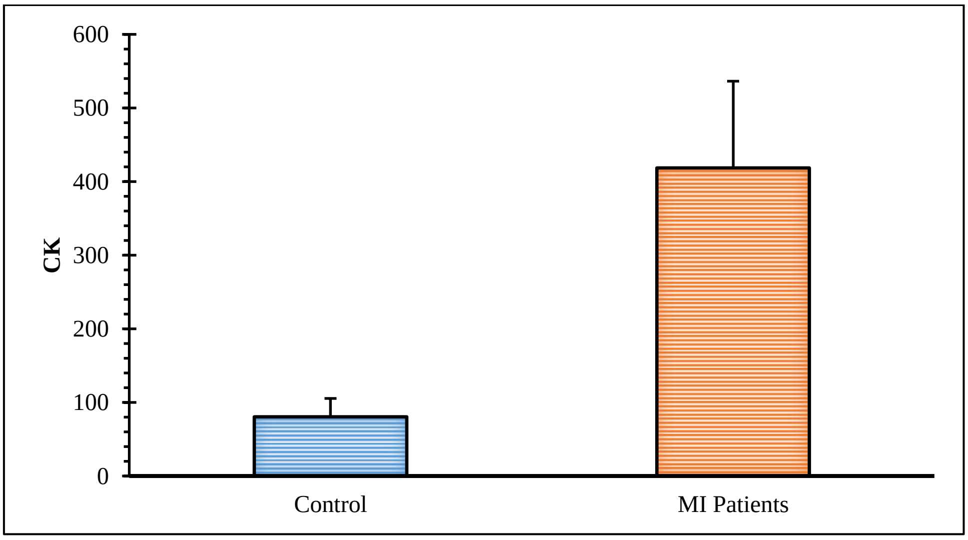

Figure 4.21 Graphic presentation of CK comparison between female myocardial infraction patients and female controls

4.7 Lactate Dehydrogenase

In Table 4.7 the LDH activity of myocardial infraction patients and controls are listed in values of mean and standard deviation for total subjects, and males and females separately.

Table 4.7 LDH activity in myocardial patients and controls

VARIABLES	CONTROL	MYOCARDIAL INFRACTION PATIENTS	P-VALUE
		LDH (U/L)	
Total	169.41±52.67	231.72±89.58	<0.001
Male	164.83±42.35	244.63±112.66	<0.001
Female	173.99±61.50	218.82±56.73	0.001

As shown in Table 4.7, the LDH activity of the total subjects (males and females) was significantly (P<0.05) different (higher) in myocardial infraction patients (231.72±89.58 U/L) compared to controls (169.41±52.67 U/L), which is graphically demonstrated in Figure 4.22.

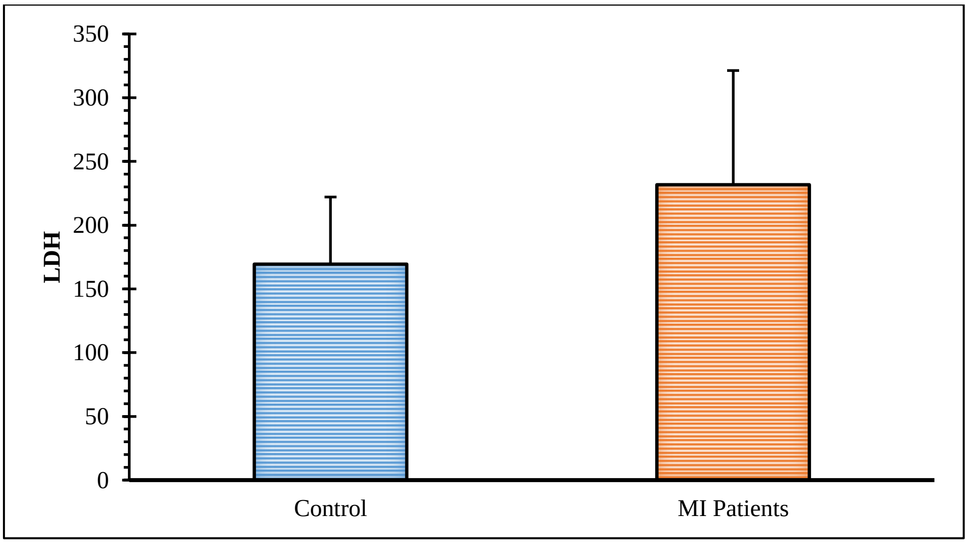

Figure 4.22 Graphic presentation of LDH comparison between myocardial infraction patients and controls

As shown in Table 4.7, the LDH activity of the male subjects was significantly (P<0.05) different (higher) in myocardial infraction patients (244.63±112.66 U/L) compared to controls (164.83±42.35 U/L), which is graphically demonstrated in Figure 4.23.

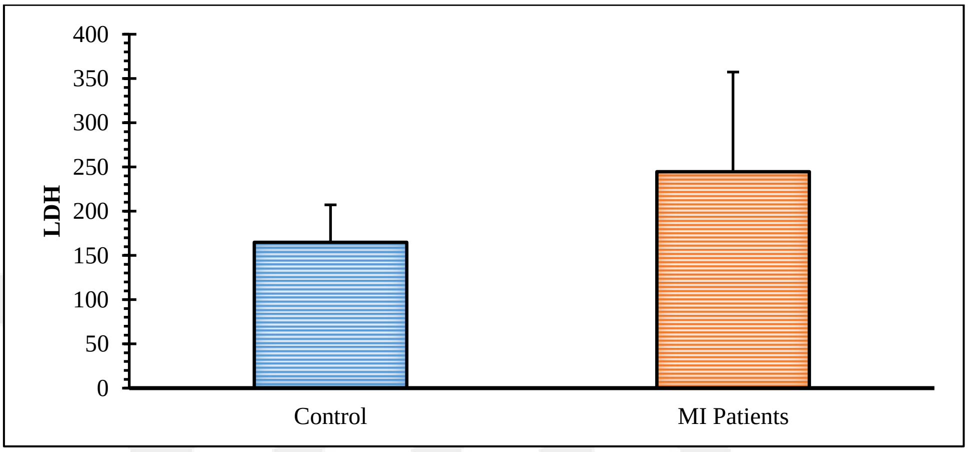

Figure 4.23 Graphic presentation of LDH comparison between male myocardial infraction patients and male controls

As shown in Table 4.7, the LDH activity of the female subjects was significantly (P<0.05) different (higher) in myocardial infraction patients (218.82±56.73 U/L) compared to controls (173.99±61.50 U/L), which is graphically demonstrated in Figure 4.24.

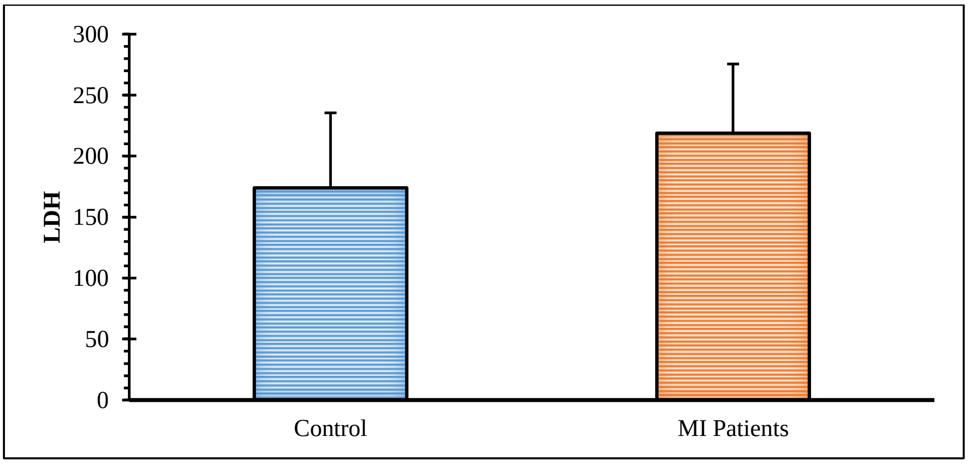

Figure 4.24 Graphic presentation of LDH comparison between female myocardial infraction patients and female controls

4.8 Aspartate Aminotransferase

In Table 4.8 the AST activity of myocardial infraction patients and controls are listed in values of mean and standard deviation for total subjects, and males and females separately.

Table 4.8 AST activity in myocardial patients and controls

VARIABLES	CONTROL	MYOCARDIAL INFRACTION PATIENTS	P-VALUE
		LDH (U/L)	
Total	19.18±4.87	70.74±14.93	<0.001
Male	17.98±3.49	68.52±9.15	<0.001
Female	20.37±5.73	72.97±18.91	<0.001

As shown in Table 4.8, the AST activity of the total subjects (males and females) was significantly ($P<0.05$) different (higher) in myocardial infraction patients (70.74±14.93 U/L) compared to controls (19.18±4.87 U/L), which is graphically demonstrated in Figure 4.25.

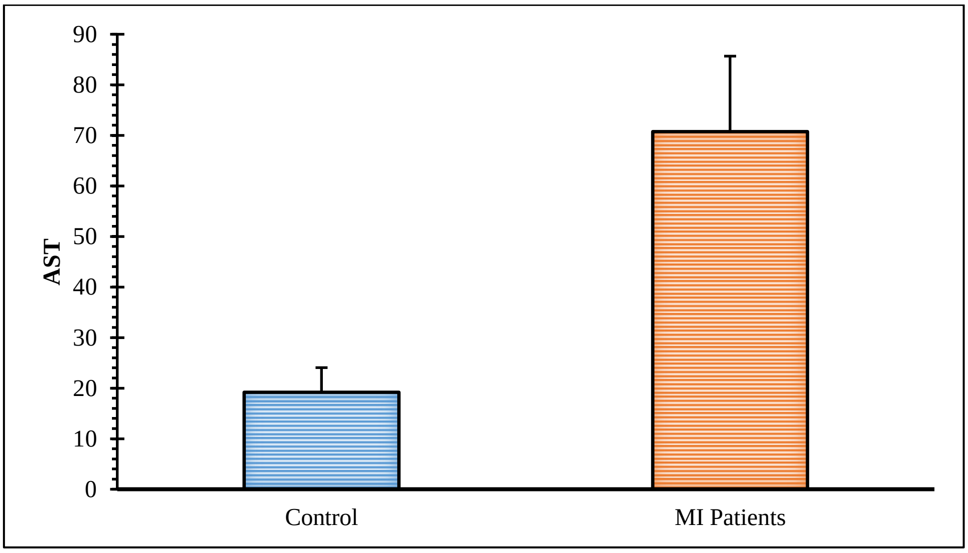

Figure 4.25 Graphic presentation of AST comparison between myocardial infraction patients and controls

As shown in Table 4.8, the AST activity of the male subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (68.52±9.15 U/L) compared to controls (17.98±3.49 U/L), which is graphically demonstrated in Figure 4.26.

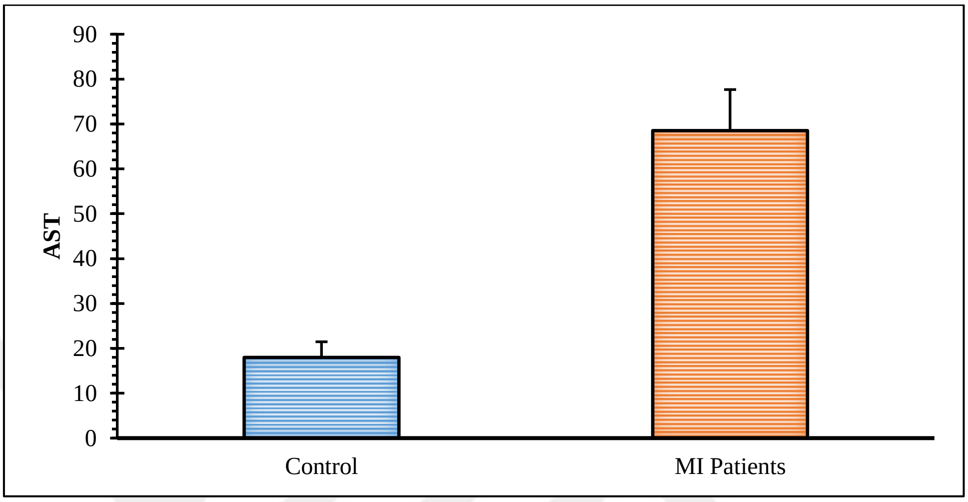

Figure 4.26 Graphic presentation of AST comparison between male myocardial infraction patients and male controls

As shown in Table 4.8, the AST activity of the male subjects was significantly ($P<0.05$) different (higher) in myocardial infraction patients (72.97±18.91 U/L) compared to controls (20.37±5.73 U/L), which is graphically shown in Figure 4.27.

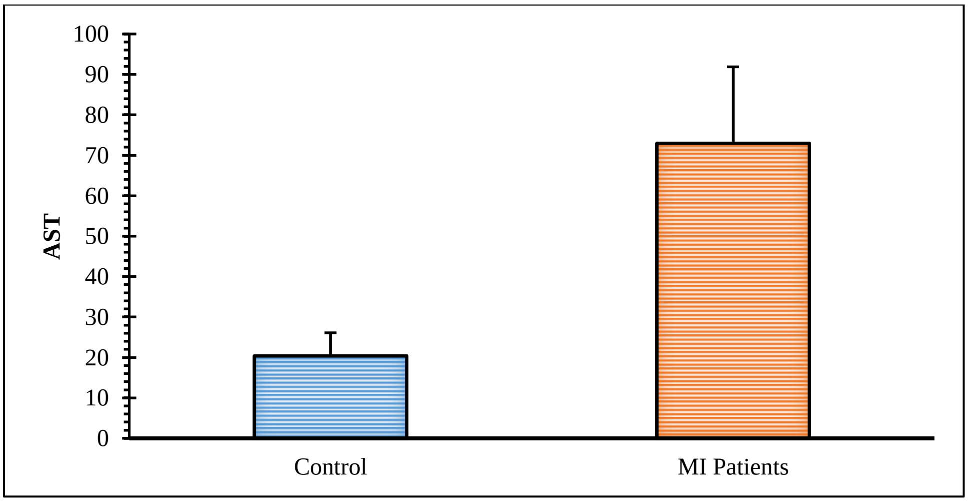

Figure 4.27 Graphic presentation of AST comparison between female myocardial infraction patients and female controls

4.9 Correlation

Table 4.9 demonstrates the observed correlations among the used variables in this study by the mean of Pearson's factor.

Table 4.9 Correlations of the variables used in the study

VARIABLE	TNFalpha		ANP		CK	
	r	P	r	P	r	P
ANP	-0.133	0.238	-	-	-0.219	0.051
CK	0.244*	0.029	-0.219	0.051	-	-
Age	0.150	0.183	-0.018	0.871	0.135	0.231
BMI	-0.160	0.156	0.014	0.899	-0.011	0.924
CRP	0.205	0.068	-0.062	0.584	0.054	0.635
Troponin t	0.034	0.766	-0.185	0.100	0.518*	0.0001
LDH	0.156	0.168	0.165	0.144	-0.018	0.876
AST	-0.115	0.310	0.055	0.627	-0.081	0.476

The patients who suffer from myocardial infraction disease were exhibited a positive correlation between TNFalpha and CK, and between Troponin t and CK, as shown in Figure 4.28.

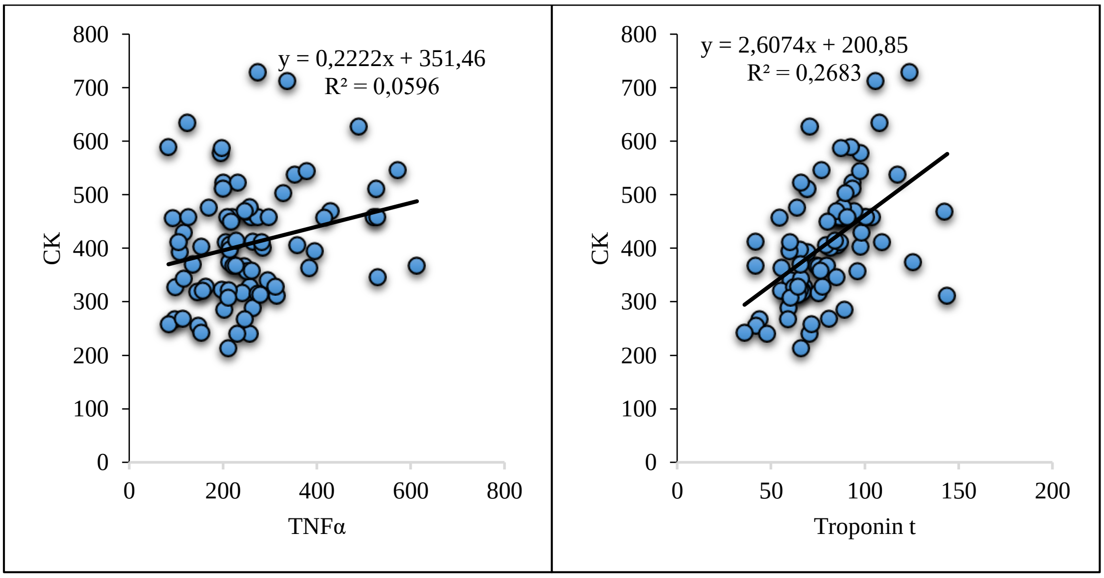

Figure 4.28 Correlation of variables in myocardial patients of this study

4.10 Receiver Operating Characteristics

Table 4.10 demonstrates the observed sensitivities among the used variables in this study by the mean of area under the curve (AUC).

Table 4.10 Correlations of the variables used in the study

Variables	AUC	SE	P-VALUE
TNFalpha	0.971	0.011	0.0001
ANP	0.597	0.046	0.035
CK	1.00	<0.001	0.0001

In order to determine the sensitivities of TNFalpha, ANP and CK, the ROC analysis was used. TNFalpha has shown excellent sensitivity for the prognosis of myocardial infraction disease, ANP was failed in the prognosis of myocardial disease, while CK activity was shown very excellent sensitivity in the prognosis of myocardial infraction disease as shown in Figure 4.29.

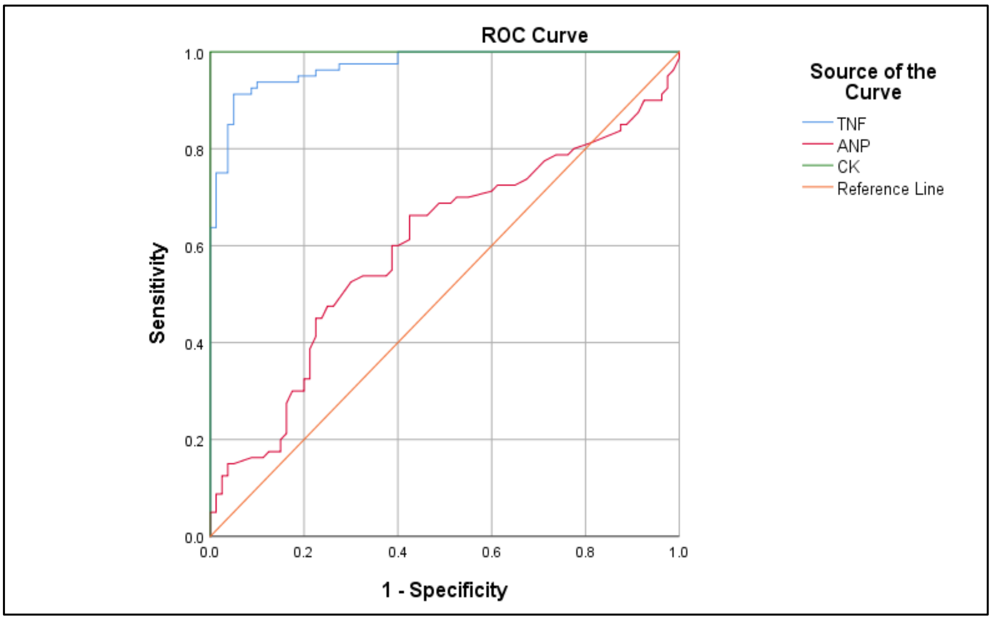

Figure 4.29 ROC analysis diagram of TNFalpha (blue), ANP (pink), and CK (green) in the prognosis of myocardial infraction disease.

5. DISCUSSION

Myocardial infraction was investigated for the fluctuations of systemic creatine kinase, tumor necrosis factor alpha, troponin t, and other biomarkers for the sensitivity of its diagnosis and the physiological effects. Wide spectrum of participants was included in this study (160 subject) with comparable age and BMI.

The level of CRP was increased significantly in both males and females with myocardial infraction. It has been used extensively as indicator for increased inflammatory processes and cardiovascular problems (McFadyen *et al.* 2020), and has been suggest for the diagnosis of myocardial infraction (Zebrack *et al.* 2002). Acute myocardial infarction causes an inflammatory response that continues for weeks or months; individuals with big infarcts and significant baseline inflammation seem to have a more severe mid-term inflammatory response (Rencuzogullari *et al.* 2019). Thus, it leads to an increase in the level of circulating CRP. Mastella *et al.* have reported that CRP increases the damage of myocardial and it corresponds with the decrease of high-density lipoprotein (Mastella *et al.* 2009).

Furthermore, both CK and troponin t were increased significantly and correlated to each other in myocardial infraction patients. According to Al-Mahdawi's research (Al-Mahdawi, 2008), myocardial patients had significantly higher CK activity compared to the control group and to patients with other cardiovascular disorders. Consistent with these findings, Ewadh *et al.* (2006) found an elevation in total CK and CK-MB activity in patients with myocardial disease. Measurements of cardiac troponin taken during the plateau period (48-72 hours following the beginning of MI symptoms) are correlated with infarct size as indicated by magnetic resonance imaging (Jenča *et al.* 2021). Kasar *et al.* have reported significant increase of troponin t in the circulation occurring in myocardial infraction patients. The authors have stated that troponin t is a reliable biomarker for the diagnosis and monitoring myocardial infraction patients from time of symptoms onset to the recovery time (Kasar *et al.* 2022).

The level of ANP was increased significantly in male (but not female) myocardial infraction patients. Natriuretic peptides have been linked to heart dysfunction and infarct size. The pattern of the increase in natriuretic peptides is also connected with negative outcomes, not only its absolute level. Patients with myocardial infarction may see an increase in brain natriuretic peptide levels, with some experiencing a monophasic pattern with a peak 16 hours after admission and others experiencing a biphasic pattern with a second peak 5 days later (McFadyen *et al.* 2020). Arakawa *et al.* (1994) have reported significant increase of BNP in the circulation of myocardial infraction patients (Arakawa *et al.* 1994). Muders *et al.* have reported significant increase of ANP in myocardial infraction patients. The authors have shown that the increase of plasma ANP level related to enhancing left ventricular dysfunction (Muders *et al.* 1997).

The patients with myocardial infraction have shown significant increase of TNFalpha, and also it was positively correlated with CK. The correlation between these two biomarkers may indicate a strong relationship between TNFalpha and myocardial infraction. Have reported that TNFalpha can raise during myocardial infraction leading to enhancing the inflammatory processes (Frangogiannis *et al.* 2002). Have reported that TNFalpha level and expression were increased significantly in myocardial infraction patients, and it can lead to heart failure in these patients (Kaur *et al.* 2006). Have shown that TNFalpha has significant role in the pathophysiology and worsening of myocardial infraction patients by increasing the inflammatory pathways (Tian *et al.* 2015).

At last, the activities of both LDH and AST were increased in myocardial infraction patients. Sobel and Shell have reported significant increase in the activity of LDH in myocardial infraction patients (Sobel and Shell, 1972). Have reported significant increase of LDH activity in the serum of myocardial infraction patients (Al-Salih *et al.* 2010), which agreed with the current results. Al-Mahdawi reported significant increase in the activity of LDH and AST in myocardial patients compared to the control of its study (Al-Mahdawi, 2008).

6. CONCLUSIONS AND RECOMMENDATION

6.1 Conclusions

1) Myocardial infraction patients have shown significant increase of CRP in both males and females.
2) The level of ANP was increased only in male myocardial infraction patients, indicating a probable gender related effect.
3) TNFalpha was increased significantly in myocardial infraction patients, and correlated strongly with CK activity which suggest a strong influence of TNFalpha on the pathophysiology of myocardial infraction.
4) Troponin t level and CK activity were both increased in myocardial infraction patients and prove their sensitivity in the prognosis of this disease.
5) The activities of LDH and AST were increased significantly in myocardial infraction patients compared to controls.
6) TNFalpha can be used as an excellent sensitive biomarker for myocardial infraction prognosis, while ANP has failed to become one.

6.2 Recommendations

1) Continuous prognosis of the inflammatory condition in myocardial infraction patients from the onset of the symptoms to weeks after this period.
2) Studying the effect of TNFalpha in heart failure patients and its correlation with serum vitamins.
3) Evaluating the level of ANP at different time intervals in myocardial infraction patients.

REFERENCES

Adams, J. E., Sicard, G. A., Allen, B. T., Bridwell, K. H., Lenke, L. G., Davila-Roman, V. G. and Jaffe, A. S. 1994. Diagnosis of perioperative myocardial infarction with measurement of cardiac troponin I. New England Journal of Medicine., 330(10): 670-674.

Agrawal, A., Gang, T. B. and Rusiñol, A. E. 2014. Recognition functions of pentameric C-reactive protein in cardiovascular disease. Mediators of Inflammation., 2014.

Al-Mahdawi, Z. M. M. 2008. Study of levels of some enzymes in patients with cardiac diseases in Tikrit City and its Suburbs. Tikrit Journal of Pure Science., 13(3).

Al-Salih, R., Al-Fartosi, K. and Batah, S. J. 2010. Study of relationship between blood parameters and oxidant-antioxidant status of patients with unstable angina pectoris and myocardial infractions. University of Thi-Qar Journal of Medicine., 4(1): 47-64.

Anderson, J. L. and Morrow, D. A. 2017. Acute myocardial infarction. New England Journal of Medicine., 376(21): 2053-2064.

Arakawa, N., Nakamura, M., Aoki, H. and Hiramori, K. 1994. Relationship between plasma level of brain natriuretic peptide and myocardial infarct size. Cardiology., 85(5): 334-340.

Babaieasl, F. 2018. Myocardial Infarction-Related Symptoms in Middle Eastern Women and Factors Influencing Their Responses to the Symptoms. Wayne State University.

Baigent, C., Blackwell, L., Emberson, J., Holland, L. E., Reith, C., Bhala, N. and Collins, R. 2010. Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170,000 participants in 26 randomised trials. Lancet (London, England)., 376(9753): 1670-1681.

Barberi, C. and Van-Den Hondel, K. E. 2018. The use of cardiac troponin T (cTnT) in the postmortem diagnosis of acute myocardial infarction and sudden cardiac death: A systematic review. Forensic science international., 292: 27-38.

Bodor, G. S. 2016. Biochemical markers of myocardial damage. Ejifcc., 27(2): 95.

Body, R., Carley, S., Wibberley, C., McDowell, G., Ferguson, J. and Mackway-Jones, K. 2010. The value of symptoms and signs in the emergent diagnosis of acute coronary syndromes. Resuscitation., 81(3): 281-286.

Bradley, J. 2008. TNF-mediated inflammatory disease. The Journal of Pathology: A Journal of the Pathological Society of Great Britain and Ireland., 214(2): 149-160.

Bruyninckx, R., Aertgeerts, B., Bruyninckx, P. and Buntinx, F. 2008. Signs and symptoms in diagnosing acute myocardial infarction and acute coronary syndrome: a diagnostic meta-analysis. British Journal of General Practice., 58(547): e1-e8.

Casanova, G., Bossardi Ramos, R., Ziegelmann, P. and Spritzer, P. M. 2015. Effects of low-dose versus placebo or conventional-dose postmenopausal hormone therapy on variables related to cardiovascular risk: a systematic review and meta-analyses of randomized clinical trials. The Journal of Clinical Endocrinology & Metabolism., 100(3): 1028-1037.

Chapman, A. R., Adamson, P. D. and Mills, N. L. 2017. Assessment and classification of patients with myocardial injury and infarction in clinical practice. Heart., 103(1): 10-18.

Chapman, A. R., Adamson, P. D., Shah, A. S., Anand, A., Strachan, F. E., Ferry, A. V. and Mills, N. L. 2020. High-sensitivity cardiac troponin and the universal definition of myocardial infarction. Circulation., 141(3): 161-171.

Chapman, A. R., Shah, A. S., Lee, K. K., Anand, A., Francis, O., Adamson, P. and Mills, N. L. 2018. Long-term outcomes in patients with type 2 myocardial infarction and myocardial injury. Circulation., 137(12): 1236-1245.

Chen, Y., Tao, Y., Zhang, L., Xu, W. and Zhou, X. 2019. Diagnostic and prognostic value of biomarkers in acute myocardial infarction. Postgraduate Medical Journal., 95(1122): 210- 216.

Çöl-Arslan, S. and Scheidereit, C. 2011. The prevalence of TNFalpha-induced necrosis over apoptosis is determined by TAK1-RIP1 interplay. PLoS One., 6(10): e26069.

Contessotto, P. and Pandit, A. 2021. Therapies to prevent post-infarction remodelling: From repair to regeneration. Biomaterials., 275: 120906.

Cullen, L., Mueller, C., Parsonage, W. A., Wildi, K., Greenslade, J. H., Twerenbold, R. and Than, M. 2013. Validation of high-sensitivity troponin I in a 2-hour diagnostic strategy to assess 30-day outcomes in emergency department patients with possible acute coronary syndrome. Journal of the American College of Cardiology., 62(14): 1242-1249.

DeFilippis, A. P., Chapman, A. R., Mills, N. L., De Lemos, J. A., Arbab-Zadeh, A., Newby, L. K. and Morrow, D. A. 2019. Assessment and treatment of patients with type 2 myocardial infarction and acute nonischemic myocardial injury. Circulation., 140(20): 1661-1678.

De-Servi, S., Mariani, M., Mariani, G. and Mazzone, A. 2005. C-reactive protein increase in unstable coronary disease: cause or effect?. Journal of the American College of Cardiology., 46(8): 1496-1502.

Devaraj, S., Singh, U. and Jialal, I. 2009. Human C-reactive protein and the metabolic syndrome. Current Opinion in Lipidology., 20(3): 182.

De-Vito, P., Incerpi, S., Pedersen, J. Z. and Luly, P. 2010. Atrial natriuretic peptide and oxidative stress. Peptides., 31(7): 1412-1419.

Doenst, T., Haverich, A., Serruys, P., Bonow, R. O., Kappetein, P., Falk, V. and Sigusch, H. 2019. PCI and CABG for treating stable coronary artery disease: JACC review topic of the week. Journal of the American College of Cardiology., 73(8): 964-976.

Ewadh, M., A Heniwa, R. and G AL-Awady, H. 2006. Biochemical Markers and Risk Factors In Acute Myocardial Infarction. journal of kerbala university., 2(2): 60-78.

Fan, D. and Kassiri, Z. 2021. Modulation of cardiac fibrosis in and beyond cells. Frontiers in Molecular Biosciences., 8, 750626.

Farhana, A. and Lappin, S. L. 2022. Biochemistry, lactate dehydrogenase. In StatPearls. StatPearls Publishing.

Federico, C. 2010. Natriuretic peptide system and cardiovascular disease. Heart views: the official journal of the Gulf Heart Association., 11(1): 10.

Finckh, U., Müller-Thomsen, T. O. M. A. S., Mann, U., Eggers, C., Marksteiner, J., Meins, W. and Gal, A. 2000. High Frequency of Mutations in Four Different Disease Genes in Early-Onset Dementia. Annals of the New York Academy of Sciences., 920(1): 100-106.

Fischman, D. L., Mahadevan, V. S. and Bates, E. R. 2023. The “Evolving” Role of Intravascular Imaging in Myocardial Infarction With Nonobstructive Coronary Arteries. Case Reports., 6: 1-3.

Fraga, D., Ellington, W. R. and Suzuki, T. 2022. The characterization of novel monomeric creatine kinases in the early branching Alveolata species, Perkinsus marinus: Implications for phosphagen kinase evolution. Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology., 262: 110758.

Frangogiannis, N. G., Smith, C. W. and Entman, M. L. 2002. The inflammatory response in myocardial infarction. Cardiovascular research., 53(1): 31-47.

French, J. K., Hellkamp, A. S., Armstrong, P. W., Cohen, E., Kleiman, N. S., O'Connor, C. M. and Mahaffey, K. W. 2010. Mechanical complications after percutaneous coronary intervention in ST-elevation myocardial infarction (from APEX-AMI). The American journal of cardiology., 105(1): 59-63.

Gaudin, A., Yemisci, M., Eroglu, H., Lepetre-Mouelhi, S., Turkoglu, O. F., Dönmez-Demir, B. and Couvreur, P. 2014. Squalenoyl adenosine nanoparticles provide neuroprotection after stroke and spinal cord injury. Nature nanotechnology., 9(12): 1054-1062.

Ghaffari, S., Hajizadeh, R., Mohammadi, T., Kavandi, H., Mohebbalizadeh, M. and Sedokani, A. 2022. The Association of Serum Lactate Dehydrogenase Levels with In-Hospital Mortality due to Pulmonary Embolism. International Cardiovascular Research Journal., 16(3).

He, L. P., Tang, X. Y., Ling, W. H., Chen, W. Q. and Chen, Y. M. 2010. Early C-reactive protein in the prediction of long-term outcomes after acute coronary syndromes: a meta-analysis of longitudinal studies. Heart., 96(5): 339-346.

Horiuchi, T., Mitoma, H., Harashima, S. I., Tsukamoto, H. and Shimoda, T. 2010. Transmembrane TNF-alpha: structure, function and interaction with anti-TNF agents. Rheumatology., 49(7): 1215-1228.

Hsiao, S. W., Ko, Y. C., Lo, C. H. and Chen, S. H. 2013. An ISM, DEI, and ANP based approach for product family development. Advanced Engineering Informatics., 27(1): 131-148.

Ibáñez, B., Heusch, G., Ovize, M. and Van de Werf, F. 2015. Evolving therapies for myocardial ischemia/reperfusion injury. Journal of the American College of Cardiology., 65(14): 1454-1471.

Jaffe, A. S., Babuin, L. and Apple, F. S. 2006. Biomarkers in acute cardiac disease: the present and the future. Journal of the American college of cardiology., 48(1): 1-11.

Jasensky, A. K., Bondzio, A., Murugaiyan, J., Siebert, U., Roesler, U., Kohn, B. and Einspanier, R. 2014. Characterization of the native C-reactive protein (cCRP) and the corresponding liver mRNA in dogs. Biochemical and Biophysical Research Communications., 452(3): 462-467.

Jenča, D., Melenovský, V., Stehlik, J., Staněk, V., Kettner, J., Kautzner, J. and Wohlfahrt, P. 2021. Heart failure after myocardial infarction: incidence and predictors. ESC heart failure., 8(1): 222-237.

Jiang, W., Xiong, Y., Li, X. and Yang, Y. 2021. Cardiac fibrosis: cellular effectors, molecular pathways, and exosomal roles. Frontiers in Cardiovascular Medicine., 8: 715258.

Jiang, Y., Yu, M., Hu, X., Han, L., Yang, K., Ba, H. and Wang, J. 2017. STAT1 mediates transmembrane TNF-alpha-induced formation of death-inducing signaling complex and apoptotic signaling via TNFR1. Cell Death & Differentiation., 24(4): 660-671.

Jin, Y. C., Kim, C. W., Kim, Y. M., Nizamutdinova, I. T., Ha, Y. M., Kim, H. J. and Chang, K. C. 2009. Cryptotanshinone, a lipophilic compound of Salvia miltiorrriza root, inhibits TNF-alpha-induced expression of adhesion molecules in HUVEC and attenuates rat myocardial ischemia/reperfusion injury in vivo. European journal of pharmacology., 614(1-3): 91-97.

Jobs, A., Collet, J. P. and Thiele, H. 2021. Optimal timing of invasive angiography in non-ST-segment elevation acute coronary syndromes—do we need more data?. European Heart Journal., 42(4): 353-354.

Jung, M., Dodsworth, M. and Thum, T. 2019. Inflammatory cells and their non-coding RNAs as targets for treating myocardial infarction. Basic Research in Cardiology., 114: 1-25.

Kang, D. O., Park, Y., Seo, J. H., Jeong, M. H., Chae, S. C., Ahn, T. H. and Kamir-Nih Registry Investigators. 2019. Time-dependent prognostic effect of high sensitivity C-reactive protein with statin therapy in acute myocardial infarction. Journal of cardiology., 74(1): 74-83.

Kasar, K. A., Al-Bahrani, M. H. and Mohsin, A. A. 2022. Interpreting Myocardial Enzymatic Biomarkers in the Setting of Acute Myocardial Infraction AMI. Journal of Techniques., 4(4): 105-110.

Kaur, K., Sharma, A. K. and Singal, P. K. 2006. Significance of changes in TNF-alpha and IL-10 levels in the progression of heart failure subsequent to myocardial infarction. American Journal of Physiology-Heart and Circulatory Physiology., 291(1): H106-H113.

Kawada-Watanabe, E., Yamaguchi, J., Sekiguchi, H., Arashi, H., Ogawa, H. and Hagiwara, N. 2020. Targeting high-sensitivity C-reactive protein levels in acute coronary syndrome patients undergoing contemporary lipid-lowering therapy: a sub-analysis of the HIJ-PROPER trial. Journal of Cardiology., 75(5): 500-506.

Kazak, L. and Cohen, P. 2020. Creatine metabolism: energy homeostasis, immunity and cancer biology. Nature Reviews Endocrinology., 16(8): 421-436.

Kishore, R., Tkebuchava, T., Sasi, S. P., Silver, M., Gilbert, H. Y., Yoon, Y. S. and Goukassian, D. A. 2011. Tumor necrosis factor-alpha signaling via TNFR1/p55 is deleterious whereas TNFR2/p75 signaling is protective in adult infarct myocardium. In Advances in TNF Family Research: Proceedings of the 12th International TNF Conference. Springer New York., 2009: 433-448.

Kitakaze, M., Asakura, M., Kim, J., Shintani, Y., Asanuma, H., Hamasaki, T. and Kitamura, S. 2007. Human atrial natriuretic peptide and nicorandil as adjuncts to reperfusion treatment for acute myocardial infarction (J-WIND): two randomised trials. The Lancet., 370(9597): 1483-1493.

Korley, F. K. and Jaffe, A. S. 2013. Preparing the United States for high-sensitivity cardiac troponin assays. Journal of the American College of Cardiology., 61(17): 1753-1758.

Lenicek-Krleza, J., Dorotic, A., Grzunov, A. and Maradin, M. 2015. Capillary blood sampling: national recommendations on behalf of the Croatian Society of Medical Biochemistry and Laboratory Medicine. Biochemia Medica., 25(3): 335-358.

Li, H. Y., Wang, J., Meng, F., Jia, Z. K., Su, Y., Bai, Q. F. and Wu, Y. 2016. An intrinsically disordered motif mediates diverse actions of monomeric C-reactive protein. Journal of Biological Chemistry., 291(16): 8795-8804.

Libby, P. 2013. Mechanisms of acute coronary syndromes and their implications for therapy. N Engl J Med., 368: 2004-2013.

Lopez, M. J., Garbers, D. L. and Kuhn, M. 1997. The guanylyl cyclase-deficient mouse defines differential pathways of natriuretic peptide signaling. Journal of Biological Chemistry., 272(37): 23064-23068.

Majmudar, M. D., Keliher, E. J., Heidt, T., Leuschner, F., Truelove, J., Sena, B. F. and Nahrendorf, M. 2013. Monocyte-directed RNAi targeting CCR2 improves infarct healing in atherosclerosis-prone mice. Circulation., 127(20): 2038-2046.

Mann, D., Zipes, D., Libby, P. and Bonow, R. 2014. Braunwalds heart disease: A textbook of cardiovascular medicine, single volume.

Mariani, M., Fetiveau, R., Rossetti, E., Poli, A., Poletti, F., Vandoni, P. and De Servi, S. 2006. Significance of total and differential leucocyte count in patients with acute myocardial infarction treated with primary coronary angioplasty. European heart journal., 27(21): 2511-2515.

Marinou, K., Tousoulis, D., Antonopoulos, A. S., Stefanadi, E. and Stefanadis, C. 2010. Obesity and cardiovascular disease: from pathophysiology to risk stratification. International journal of cardiology., 138(1): 3-8.

Mastella, A. K., Moresco, R. N., da Silva, D. B., Becker, A. M., Duarte, M. M., Giovelli, L. L. and da Silva, J. E. P. 2009. Evaluation of ischemia-modified albumin in myocardial infarction and prostatic diseases. Biomedicine & pharmacotherapy., 63(10): 762-766.

McCarthy, C. P., Vaduganathan, M., McCarthy, K. J., Januzzi, J. L., Bhatt, D. L. and McEvoy, J. W. 2018. Left ventricular thrombus after acute myocardial infarction: screening, prevention, and treatment. JAMA cardiology., 3(7): 642-649.

McFadyen, J. D., Zeller, J., Potempa, L. A., Pietersz, G. A., Eisenhardt, S. U. and Peter, K. 2020. C-reactive protein and its structural isoforms: an evolutionary conserved marker and central player in inflammatory diseases and beyond. Vertebrate and invertebrate respiratory proteins, lipoproteins and other body fluid proteins., 499-520.

McGrath, M. F. and De-Bold, A. J. 2005. Determinants of natriuretic peptide gene expression. Peptides., 26(6): 933-943.

Mehta, S. R., Cannon, C. P., Fox, K. A., Wallentin, L., Boden, W. E., Spacek, R. and Yusuf, S. 2005. Routine vs selective invasive strategies in patients with acute coronary syndromes: a collaborative meta-analysis of randomized trials. Jama., 293(23): 2908-2917.

Mensah, G. A., Roth, G. A. and Fuster, V. 2019. The global burden of cardiovascular diseases and risk factors: 2020 and beyond. Journal of the American College of Cardiology., 74(20): 2529-2532.

Mihos, C. G., Pineda, A. M. and Santana, O. 2014. Cardiovascular effects of statins, beyond lipid-lowering properties. Pharmacological research., 88: 12-19.

Mikolajek, H., Kolstoe, S. E., Pye, V. E., Mangione, P., Pepys, M. B. and Wood, S. P. 2011. Structural basis of ligand specificity in the human pentraxins, C-reactive protein and serum amyloid P component. Journal of Molecular Recognition., 24(2): 371-377.

Moreyra, A. E., Huang, M. S., Wilson, A. C., Deng, Y., Cosgrove, N. M., Kostis, J. B. and MIDAS Study Group. 2010. Trends in incidence and mortality rates of ventricular septal rupture during acute myocardial infarction. The American journal of cardiology., 106(8): 1095-1100.

Morita, C., Horiuchi, T., Tsukamoto, H., Hatta, N., Kikuchi, Y., Arinobu, Y. and Niho, Y. 2001. Association of tumor necrosis factor receptor type II polymorphism 196R with Systemic lupus erythematosus in the Japanese: molecular and functional analysis. Arthritis & Rheumatism: Official Journal of the American College of Rheumatology., 44(12): 2819-2827.

Muders, F., Kromer, E. P., Griese, D. P., Pfeifer, M., Hense, H.-W., Riegger, G. A. and Elsner, D. 1997. Evaluation of plasma natriuretic peptides as markers for left ventricular dysfunction. American Heart Journal., 134(3): 442-449.

Mueller, M., Vafaie, M., Biener, M., Giannitsis, E. and Katus, H. A. 2013. Cardiac Troponin T–From Diagnosis of Myocardial Infarction to Cardiovascular Risk Prediction–. Circulation Journal., 77(7): 1653-1661.

Ngwa, D. N., Pathak, A. and Agrawal, A. 2022. IL-6 regulates induction of C-reactive protein gene expression by activating STAT3 isoforms. Molecular Immunology., 146, 50-56.

Ohta, H., Wada, H., Niwa, T., Kirii, H., Iwamoto, N., Fujii, H. and Seishima, M. 2005. Disruption of tumor necrosis factor-alpha gene diminishes the development of atherosclerosis in ApoE-deficient mice. Atherosclerosis., 180(1): 11-17.

O'Rourke, R. A. and Dell'Italia, L. J. 2004. Diagnosis and management of right ventricular myocardial infarction. Current problems in cardiology., 29(1): 6-47.

Pathak, A. and Agrawal, A. 2019. Evolution of C-reactive protein. Frontiers in Immunology., 10: 943.

Peteiro, J. and Bouzas-Mosquera, A. 2017. Novelties on Stress Echocardiography for the Assessment of Ischemia. Int Arch Intern Med., 1(001).

Pobezinskaya, Y. L. and Liu, Z. 2012. The role of TRADD in death receptor signaling. Cell Cycle., 11(5): 871-876.

Prabhu, S. D. and Frangogiannis, N. G. 2016. The biological basis for cardiac repair after myocardial infarction: from inflammation to fibrosis. Circulation Research., 119(1): 91-112.

Puerto, E., Viana-Tejedor, A., Martínez-Sellés, M., Domínguez-Pérez, L., Moreno, G., Martín-Asenjo, R. and Bueno, H. 2018. Temporal trends in mechanical complications of acute myocardial infarction in the elderly. Journal of the American College of Cardiology., 72(9): 959-966.

Rahmani, R., Majidi, B., Ariannejad, H. and Shafiee, A. 2020. The value of the grace score for predicting the syntax score in patients with unstable angina/non-ST elevation myocardial infarction. Cardiovascular Revascularization Medicine., 21(4): 514-517.

Rao, S. V., Schulman, K. A., Curtis, L. H., Gersh, B. J. and Jollis, J. G. 2004. Socioeconomic status and outcome following acute myocardial infarction in elderly patients. Archives of Internal Medicine., 164(10): 1128-1133.

Reddy, K., Khaliq, A. and Henning, R. J. 2015. Recent advances in the diagnosis and treatment of acute myocardial infarction. World Journal of Cardiology., 7(5): 243.

Rencuzogullari, I., Karabağ, Y., Çağdaş, M., Karakoyun, S., Seyis, S., Gürsoy, M. O. and Tanboğa, İ. H. 2019. Assessment of the relationship between preprocedural

C-reactive protein/albumin ratio and stent restenosis in patients with ST-segment elevation myocardial infarction. Revista Portuguesa de Cardiologia., 38(4): 269-277.

Rogers, W. J., Frederick, P. D., Stoehr, E., Canto, J. G., Ornato, J. P., Gibson, C. M. and National Registry of Myocardial Infarction Investigators. 2008. Trends in presenting characteristics and hospital mortality among patients with ST elevation and non-ST elevation myocardial infarction in the National Registry of Myocardial Infarction from 1990 to 2006. American Heart Journal., 156(6): 1026-1034.

Roth, G. A., Mensah, G. A. and Fuster, V. 2020. The global burden of cardiovascular diseases and risks: a compass for global action. Journal of the American College of Cardiology., 76(25): 2980-2981.

Sabatine, M. S., Bergmark, B. A., Murphy, S. A., T O'Gara, P., Smith, P. K., Serruys, P. W. and Braunwald, E. 2021. Percutaneous coronary intervention with drug-eluting stents versus coronary artery bypass grafting in left main coronary artery disease: an individual patient data meta-analysis. The Lancet., 398(10318): 2247-2257.

Sagnella, G. A. 1998. Measurement and significance of circulating natriuretic peptides in cardiovascular disease. Clinical Science., 95(5): 519-529.

Saito, Y. 2010. Roles of atrial natriuretic peptide and its therapeutic use. Journal of Cardiology., 56(3): 262-270.

Sánchez, P. L., Rodríguez, M. V., Villacort, E., Albarrán, C., Cruz, I., Moreiras, J. M. and Martín-Luengo, C. 2006. Kinetics of C-reactive protein release in different forms of acute coronary syndrome. Revista Española de Cardiología (English Edition)., 59(5): 441-447.

Shiraishi, J., Kohno, Y., Sawada, T., Nishizawa, S., Arihara, M., Hadase, M. and Matsubara, H. 2006. Relation of obesity to acute myocardial infarction in Japanese patient’s differences in gender and age. Circulation Journal., 70(12): 1525-1530.

Shrivastava, A. K., Singh, H. V., Raizada, A. and Singh, S. K. 2015. C-reactive protein, inflammation and coronary heart disease. The Egyptian Heart Journal., 67(2): 89-97.

Sobel, B. E. and Shell, W. E. 1972. Serum enzyme determinations in the diagnosis and assessment of myocardial infarction. Circulation., 45(2): 471-482.

Stone, N. J., Robinson, J. G., Lichtenstein, A. H., Bairey Merz, C. N., Blum, C. B., Eckel, R. H. and Wilson, P. W. 2014. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation., 129(25_suppl_2): S1-S45.

Storrow, A. B., Apple, F. S., Wu, A. H., Jesse, R. L., Francis, G. S., Christenson, R. H. and Tang, W. 2007. National academy of clinical biochemistry laboratory medicine practice guidelines: Point of care testing, oversight, and administration of cardiac biomarkers for acute coronary syndromes. Point of Care., 6(4): 215-222.

Suleiman, M., Khatib, R., Agmon, Y., Mahamid, R., Boulos, M., Kapeliovich, M. and Aronson, D. 2006. Early inflammation and risk of long-term development of heart failure and mortality in survivors of acute myocardial infarction: predictive role of C-reactive protein. Journal of the American College of Cardiology., 47(5): 962-968.

Thygesen, K., Alpert, J. S., Jaffe, A. S., Chaitman, B. R., Bax, J. J., Morrow, D. A. and Executive Group on behalf of the Joint European Society of Cardiology (ESC)/American College of Cardiology (ACC)/American Heart Association (AHA)/World Heart Federation (WHF) Task Force for the Universal Definition of Myocardial Infarction. 2018. Fourth universal definition of myocardial infarction 2018. Journal of the American College of Cardiology., 72(18): 2231-2264.

Tian, M., Yuan, Y.-C., Li, J.-Y., Gionfriddo, M. R. and Huang, R.-C. 2015. Tumor necrosis factor-alpha and its role as a mediator in myocardial infarction: a brief review. Chronic Diseases and Translational Medicine., 1(1): 18-26.

Tokudome, T. and Otani, K. 2022. Molecular Mechanism of Blood Pressure Regulation through the Atrial Natriuretic Peptide. Biology., 11(9): 1351.

Viola, M., de Jager, S. C. and Sluijter, J. P. 2021. Targeting inflammation after myocardial infarction: a therapeutic opportunity for extracellular vesicles?. International Journal of Molecular Sciences., 22(15): 7831.

Vishawanath, T., Sumana, S. and Sharanagouda, J. 2023. Application of enzymes in disease diagnosis. enzymes-mechanisms and action., 25.

Wang, L., Liu, W., He, X., Chen, Y., Lu, J., Liu, K. and Yin, P. 2016. Association of overweight and obesity with patient mortality after acute myocardial infarction: a meta-analysis of prospective studies. International journal of obesity., 40(2): 220-228.

Wang, X. Y., Zhang, F., Zhang, C., Zheng, L. R. and Yang, J. 2020. The biomarkers for acute myocardial infarction and heart failure. BioMed research international., 2020.

Wang, X., Guo, Z., Ding, Z. and Mehta, J. L. 2018. Inflammation, autophagy, and apoptosis after myocardial infarction. Journal of the American Heart Association., 7(9): e008024.

Wang, Y., Zhao, J., Zhang, Y., Lau, W. B., Jiao, L. Y., Liu, B. and Ma, X. L. 2013. Differential regulation of TNF receptor 1 and receptor 2 in adiponectin expression following myocardial ischemia. International journal of cardiology., 168(3): 2201-2206.

Weil, B. R. and Neelamegham, S. 2019. Selectins and immune cells in acute myocardial infarction and post-infarction ventricular remodeling: pathophysiology and novel treatments. Frontiers in immunology., 10: 300.

Westbrook, A. M., Wei, B., Hacke, K., Xia, M., Braun, J. and Schiestl, R. H. 2012. The role of tumour necrosis factor-alpha and tumour necrosis factor receptor signalling in inflammation-associated systemic genotoxicity. Mutagenesis., 27(1): 77-86.

Wong, G. C., Morrow, D. A., Murphy, S., Kraimer, N., Pai, R., James, D. and Gibson, C. M. 2002. Elevations in troponin T and I are associated with abnormal tissue level perfusion: a TACTICS-TIMI 18 substudy. Circulation., 106(2): 202-207.

Wu, X., Reboll, M. R., Korf-Klingebiel, M. and Wollert, K. C. 2021. Angiogenesis after acute myocardial infarction. Cardiovascular research., 117(5): 1257-1273.

Xiao, Q., Yang, Y., Qin, Y., He, Y. H., Chen, K. X., Zhu, J. W. and Luo, J. D. 2015. AMP-activated protein kinase-dependent autophagy mediated the protective effect of sonic hedgehog pathway on oxygen glucose deprivation-induced injury of cardiomyocytes. Biochemical and Biophysical Research Communications., 457(3): 419-425.

Yu, H. Y., Liu, A. K., Qiu, W. Y., Su, J., Zhou, X. Y., Gong, N. and Yang, Q. H. 2023. ‘I'm still young… it doesn't matter’–A qualitative study on the neglect of prodromal myocardial infarction symptoms among young-and middle-aged adults. Journal of Advanced Nursing., 79(1): 332-342.

Zebrack, J. S., Anderson, J. L., Maycock, C. A., Horne, B. D., Bair, T. L., Muhlestein, J. B. and Group, I. H. C. S. 2002. Usefulness of high-sensitivity C-reactive protein in predicting long-term risk of death or acute myocardial infarction in patients with unstable or stable angina pectoris or acute myocardial infarction. The American journal of cardiology., 89(2): 145-149.

Zeller, J., Cheung Tung Shing, K. S., Nero, T. L., McFadyen, J. D., Krippner, G., Bogner, B. and Eisenhardt, S. U. 2023. A novel phosphocholine-mimetic inhibits a pro-inflammatory conformational change in C-reactive protein. EMBO Molecular Medicine., 15(1): e16236.

Zhu, J., Su, X., Li, G., Chen, J., Tang, B. and Yang, Y. 2014. The incidence of acute myocardial infarction in relation to overweight and obesity: a meta-analysis. Archives of Medical Science., 10(5): 855-862.

CURRICULUM VITAE

Personal Information

Name and Surname : Mohammed Muneer Noori AL-JANABI

Education

MSc	Çankırı Karatekin University Graduate School of Natural and Applied Sciences Department of Chemistry	2021-2023
Undergraduate	Çankırı Karatekin University Faculty of Engineering Department of Chemistry	2015-2019