# COMPUTED TOMOGRAPHY ANGIOGRAPHY IN THE MANAGEMENT OF LOWER LIMB PERIPHERAL ARTERIAL DISEASE AT MOI TEACHING AND REFERRAL HOSPITAL, KENYA.

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**A THESIS SUBMITTED TO MOI UNIVERSITY, SCHOOL OF MEDICINE IN PARTIAL FULFILLMENT OF REQUIREMENT FOR THE AWARD OF THE DEGREE MASTER OF MEDICINE IN DIAGNOSTIC RADIOLOGY AND IMAGING.**

# DECLARATION

**Declaration by the student**

I declare that this thesis proposal is my original work written in partial fulfillment for the award of a Master of Medicine in Diagnostic Radiology and Imaging and has not been submitted to any other university or organization.

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## DEDICATION

I would like to dedicate this work to God, to my family for the support they have given me, to my fellow radiology students for the motivation and guidance. I am truly grateful.

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I wish to thank the almighty God for giving me the chance to undertake this study. I would like to show my gratitude to my supervisors Dr. J.M. Abuya and Dr. P. Kituyi for the assistance accorded to me. I am obliged to many of my colleagues who supported me with guidance and motivation.

# ABBREVIATIONS

| | |
|---|---|
| **2D** | Two-diemnsional |
| **3D** | Three dimensional |
| **CFA** | Common FemoralArtery |
| **CTA** | Computed Tomography Angiography Scan |
| **CTO** | Chronic Total Occlusion |
| **DM** | Diabetes Mellitus |
| **HIV** | Human Immunodefficiency Virus |
| **IREC** | Institutional Research and Ethics Committee |
| **MSCTA** | Multi Slice Computed Tomography Angiography |
| **MTRH** | Moi Teaching and Referral Hospital |
| **MUSOM** | Moi University School of Medicine |
| **PAD** | Peripheral Arterial Disease |
| **PVD** | Peripheral Vascular Disease |
| **SFA** | Superficial Femoral Artery |
| **USA** | United States of America |

## OPERATIONAL DEFINITION OF TERMS

1. **Claudication:** Cramping muscular pain in the lower limbs induced by exercise and relieved by rest.
2. **Limb threatening ischaemia:** Ulcers, gangrene or ischaemic rest pain >2 weeks, attributed to lower limb peripheral arterial disease (PAD).
3. **Non-limb threatening ischaemia:** Severe limb hypoperfusion of less than two weeks in duration.
4. **Peripheral arterial disease (PAD):** A slow and progressive disease of the circulatory system outside of the brain and heart affecting lower extremities than upper extremities.

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# ABSTRACT

**Background:** Peripheral arterial disease (PAD) is a slow and progressive disease of the lower extremities characterised by stenosis or occlusion of the arteries and a major cause of morbidity globally. In the past decade, Computer Tomography Angiography (CTA) has become a standard non-invasive imaging modality for the depiction of vascular anatomy and pathology.

**Objective:** To describe CTA as a diagnostic tool and treatment planning in peripheral artery disease of the lower limbs.

**Methods:** This was a descriptive cross-sectional study conducted among 66 patients with peripheral artery disease of the lower limbs at the Radiology and Imaging department of Moi Teaching and Referral Hospital (MTRH) between September 2021 and August 2022. Imaging findings from CTA were documented, detailing anatomical artery involved and extent in the same questionnaire. Fisher's exact test was used to test the association between diagnosis and CTA findings, as well as the relationship between CTA findings and treatment plan calculated. Likelihood ratios between predictor and outcome variables were computed at 95% confidence interval.

**Results:** On CTA, 56.1% had occlusions. The posterior tibial artery had highest occlusions at 39.4% with a statistically significant association between CTA findings and claudication of walking less than 200 meters noted. Additionally, CTA findings directly influenced the surgical intervention offered.

**Conclusions:** Majority of those enrolled were elderly males with claudication of walking less than 200 meters. The most common CTA finding was posterior tibial occlusion. CTA findings were significantly associated with surgical management plan.

**Recommendations:** This study stimulates further inquiry and scholarship, creating the need for a larger study to elucidate additional risk factors.

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background of Study

A Multislice Computed Tomography Angiography (MSCTA) is a non-invasive imaging modality (Abdelfattah et al., 2014) . MSCTA is increasingly being used for evaluation and diagnosis of peripheral arterial disease (PAD) of the lower limbs. This is due to its non-invasive technique, requires only venous access for contrast injection, has minimal risks easily tolerated (Ozkan et al., 2013). For this reason, it is an outpatient procedure. MSCTA offers volume coverage with decreased dose of contrast medium and faster acquisition time (Osama et al., 2012). This has improved in image acquisition of ill, emergency patients and children. MSCTA has improved spatial resolution for the assessment of smaller arterial branches (Abd-Elgawad et al., 2013). Improvements in MSCTA has led to decreased radiation dose exposure. In a study of 30 patients conducted in China (Duan et al., 2013a), , the mean radiation dose index was 3.71 ± 0.8mGy, the effective dose was 1.94 ± 0.21mSv for CTA and 4.41 ± 0.64mSv for conventional angiography.

Computed Tomography Angiography is well established to assess the cardiovascular system, it has the added benefit of visualising the entire vessel from its origin to target structure even tortuous vessels (Syed et al., 2019a). It can identify adverse plaque features using non-invasive techniques and characterise plaque morphology (Hong et al., 2021). It has the spatial resolution to detect focal luminal stenosis. It is also well suited to visualize vessel calcification (Tanaka et al., 2019).

Computed Tomography Angiography provides accurate anatomical imaging which is part of routine clinical care (Mishra et al., 2017). Conventional angiography is currently used as the gold standard for detecting peripheral vascular diseases, however, it is associated with multiple complications as it is an invasive procedure (Soulez et al., 2008). The complications range from puncture site haematoma (5.4%), pseudoaneurysm at puncture site (1.2%), retroperitoneal haematoma (0.5%), distal embolization (1.5%) and arteriovenous fistula at popliteal puncture site estimated at 0.5% (Patel et al., 2013). Computer-tomography angiography (CTA) has been more accepted compared to conventional angiography, making it the undisputed diagnostic reference standard for vascular disease for the last 70 years (J. M. Lee et al., 2023). This is because it is the preferred modality for the diagnosis and characterization of most cardiovascular abnormalities. Selected clinical challenges, which include acute aortic syndromes, peripheral vascular disease, aortic stent-graft and transcatheter aortic valve assessment, and coronary artery disease, are presented as contrasting examples of how CT angiography is changing our approach to cardiovascular disease diagnosis and management (Rubin, 2014). The use of multi-slice CTA is ideal in the assessment of the anatomy and pathology of the vascular tree of the lower limbs with a submillimeter spatial resoltuion and high temporal resolution (Baliyan et al., 2019a).

Treatment planning for peripheral arterial disease (PAD) of the lower extremities necessitates precise visualization of the blood vessels (Normahani et al., 2022). Traditionally, angiography has been the go-to imaging technique; however, it is invasive, involving the puncturing of arteries, the administration of contrast agents into the blood vessels, and exposure to radiation (Paton et al., 2023). Moreover, angiography is linked to both local and systemic complications, which require further attention and care. In recent years, there has been a growing demand for non-invasive imaging modalities that can provide accurate anatomical details of the vasculature in PAD patients (Shabani Varaki et al., 2018). Non-invasive techniques offer numerous advantages over angiography, including reduced patient discomfort, minimized risks, and increased convenience (Tanaka et al., 2019). These alternatives have proven to be effective in aiding treatment planning and decision-making (Keddie et al., 2022). Computed tomography angiography (CTA) is another non-invasive imaging modality utilized in the treatment planning of PAD (Đurović Sarajlić et al., 2019). It combines the principles of CT scanning and angiography to generate three-dimensional images of the vasculature (Fahrni et al., 2022). It employs a contrast medium injected into the patient's veins to enhance the visualization of blood vessels during the CT scan (Asbach et al., 2014; Staub et al., 2013). The use of CTA has proven to be highly effective in detecting arterial abnormalities, such as narrowing or occlusion, and provides essential information for treatment planning (Gruschwitz et al., 2023). These non-invasive imaging modalities play a crucial role in the treatment planning process for PAD (De Vos et al., 2014). They assist clinicians in determining the most appropriate therapeutic interventions, such as medical management, endovascular procedures, or surgical interventions. Accurate visualization of the vasculature aids in identifying the location, extent, and severity of arterial lesions, helping clinicians select the most suitable treatment options for each patient (Horehledova et al., 2018).

## 1.2 Problem Statement

Peripheral arterial disease of the lower limbs is a major cause of morbidity globally, highly prevalent in older patients. Among these patients, decreased perfusion in the lower extremities greatly impairs wound healing, causing recurrent ulceration, infection, or necrosis and surgical intervention is often necessary (Janhofer et al., 2019).The findings of a study conducted at Tenwek Hospital show that diabetic gangrene is a major cause for amputation with 6 to 43% among diabetic outpatients culminating to amputations. This could be attributed to the fact that diabetes is a rising cause of morbidity in both rural and urban regions of Kenya and is coupled with both cardiovascular and peripheral vascular disease (Ogeng'o et al., 2010). Currently, there are multiple ways for diagnosing PAD of the lower limbs, the gold standard has been intra-arterial catheter contrast conventional angiography. Compared to conventional angiography, CTA is highly accurate for assessing PAD in all regions of the lower extremities. It is used to evaluate the arterial wall, detect peripheral aneurysm, assess plaque characteristics, and identify intimal hyperplasia, defining vascular anatomy prior to interventions (Hong et al., 2021). The Transatlantic Inter-Society Consensus (TASC) guidelines recommend appropriate endovascular or surgical treatment of PAD based on lesion location, number, severity, length and morphology (Normahani et al., 2022).

Diagnostic angiography is the gold standard to visualize luminal narrowing in the lower limbs, however, does not image the arterial wall or inform the biological activity within it (Syed et al., 2019).

The non-invasive nature of CTA offers numerous advantages over invasive procedures, such as conventional angiography, which require catheterization and contrast injections (Tanaka et al., 2019). The use of CTA eliminates the need for invasive interventions, minimizing patient discomfort, and reducing the risk of complications associated with invasive procedures (Mustapha et al., 2013). This non-invasive approach is particularly beneficial for patients who may be at higher risk or have contraindications for invasive techniques (Gruschwitz et al., 2023).

Another significant advantage of CTA is its ability to provide three-dimensional reconstructions of the vascular system. These reconstructions enhance the visualization and understanding of complex anatomical structures, facilitating accurate diagnosis and treatment planning. Physicians can navigate through the reconstructed images and obtain detailed information about the vessel's course, size, and potential areas of concern, improving overall diagnostic accuracy and patient care.

The widespread availability and technological advancements in CTA have contributed to its increasing utilization in clinical practice. With the development of faster acquisition times, improved image quality, and reduced radiation exposure, CTA has become an essential tool in the diagnosis, evaluation, and management of peripheral arterial disease (Sayed et al., 2016).

This study therefore aimed to determine the specific clinical indications for CTA, the radiographic findings and resultant management approaches offered to patients with peripheral arterial disease of the lower limbs at Moi Teaching and Referral Hospital in Western Kenya.

## 1.3 Justification

Proper evaluation of the aetiology affected vasculature and medical history is important to select appropriate treatment and improve patient outcome (Wallace et al., 2019). This is achieved by reducing on their disease burden and its associated treatment cost through conducting targeted clinical studies on different demographic subsets who are more predisposed to the condition.

Identification of the most common clinical diagnosis among patients indicated for MS-CTA will help both clinical and imaging staff in developing predictive models for patients requiring this diagnostic approach. The study further determined the resulting interventions the patients receive to evaluate whether the results of CTA are adequately utilized and influence the overall care the patient finally received. The effect of therapeutic interventions may be validated with imaging (Syed et al., 2019a)

In addition to aiding treatment planning, non-invasive imaging techniques also provide valuable preoperative information. They allow surgeons to assess the feasibility of different treatment approaches and anticipate potential challenges during interventions. This knowledge enhances surgical precision and reduces the risk of complications (Martinelli et al., 2020).

In summary, the traditional use of invasive angiography in treatment planning for PAD is being replaced by non-invasive imaging modalities that offer numerous advantages. Magnetic resonance angiography, computed tomography angiography, and ultrasound provide accurate anatomical details of the vasculature without the need for invasive procedures or exposure to radiation.

CTA plays a crucial role in the treatment planning process for PAD. It assists clinicians in determining the most appropriate therapeutic interventions, such as medical management, endovascular procedures, or surgical interventions. Accurate visualization of the vasculature aids in identifying the location, extent, and severity of arterial lesions, helping clinicians select the most suitable treatment options for each patient. In addition to aiding treatment planning, non-invasive imaging techniques also provide valuable preoperative information. They allow surgeons to assess the feasibility of different treatment approaches and anticipate potential challenges during interventions. This knowledge enhances surgical precision and reduces the risk of complications (De Vos et al., 2014).

The findings of a study published in the Western vascular society, indicate that the success of endovascular treatment for occlusions in the superficial femoral artery-popliteal (SFA-pop) region is influenced by preoperative CTA results (Itoga et al., 2017a).

The results of this study can be utilized by hospital's management in developing hospital specific diagnostic guidelines and treatment strategies for peripheral arterial disease of the lower limbs using MS-CTA as a potential alternative to conventional angiography as these techniques play a vital role in treatment planning, facilitating the selection of appropriate interventions and enhancing patient care throughout the entire treatment process in many clinical settings in Kenya.

## 1.4 Research Question

How do CTA findings influence management of lower limb peripheral arterial disease at Moi Teaching and Referral Hospital?

## 1.5 Objectives

### 1.5.1 Broad Objective

To describe CTA in the management of lower limb PAD at Moi Teaching and Referral Hospital (MTRH).

### 1.5.2 Specific Objectives

1. To describe the clinical presentation of the patients with peripheral arterial disease of the lower limbs at MTRH.
2. To describe the CTA findings of the lower limbs in patients with PAD at MTRH.
3. To analyse the association between CTA findings and treatment plans for patients with peripheral vascular disease of the lower limbs seen at MTRH.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Epidemiology and demographics of peripheral arterial disease

Peripheral vascular disease (PVD) is a slow and progressive disease or disorder of the circulatory system outside of the brain and heart. Sometimes also referred to as peripheral arterial disease (PAD). It is characterised by stenosis and/or occlusion of large and medium-sized arteries. PAD affects the lower extremities more than the upper extremity vessels (Shu & Santulli, 2018). Globally, over 200 million individuals are believed to be affected by peripheral artery disease (PAD), exhibiting a range of symptoms that vary from minimal to severe (Fowkes et al., 2017). PAD is more prevalent in older individuals, with a relatively lower occurrence among younger people (Thiruvoipati, 2015). Its frequency increases with age and significantly impacts a considerable portion of the elderly population, exceeding 20% in individuals aged 80 and above (Criqui et al., 2021).

Despite being a widely prevalent condition, Peripheral Artery Disease (PAD) is often overlooked and inadequately addressed, leading to decreased functional abilities and heightened risks of cardiovascular morbidity and mortality (Shu & Santulli, 2018). Furthermore, PAD's connections to mortality rates, morbidity incidents, and diminished quality of life are not adequately recognized and addressed (McDermott et al., 2008). PAD is a heterogeneous group of occlusive arteial conditions involving moslty the lower limbs (Syed et al., 2019).

Vascular diseases result from circulatory system dysfunction caused by damage, occlusion and/or inflammation of arteries and/or veins (Baliyan et al., 2019). Peripheral arterial disease (PAD), chronic venous disease (CVD), which includes chronic venous insufficiency (CVI) and deep vein thrombosis (DVT), are common types of PVDs and are the most prevalent in the lower extremities (Meyersohn et al., 2015). Arterial emboli, peripheral aneurysm with embolus or thrombosis, and direct arterial trauma are additional, less common causes (Axley et al., 2020a). It was noted that PAD affects 10-15% of the population and about 20% of people aged over 60 years. Worldwide the incidence has increased from 164 million in 2002 to 202 million in 2010 (Shabani Varaki et al., 2018).

PAD is common in the United States affecting around 8 million Americans (Aboyans et al., 2012; Criqui et al., 2021; Gerhard-Herman et al., 2017). Men present to physicians more frequently. Though when screening is performed on asymptomatic individuals, women appear to be affected as commonly as men (Narang & Budoff, 2023). Blacks are more affected than other races (Shu & Santulli, 2018).

Patients with PAD have a 15–30% five-year mortality rate and a 2-6-fold increased risk of death from coronary heart disease (Hashimoto et al., 2017). Mortality being highest in those with more severe PAD like critical limb ischemia. PAD is associated with reduced functional capacity and increased risk of cardiovascular morbidity and mortality. PAD remains overall underdiagnosed and untreated (Shu & Santulli, 2018).

Worldwide data suggests that Southeast Asia and Western Pacific regions have the highest number of patients diagnosed with PAD (E. B. Wu et al., 2018). It is worth noting that a significant portion of individuals with PAD do not exhibit any symptoms (Alahdab et al., 2015; Mohler et al., 2012). Among those who do experience symptoms, a considerable proportion suffer from atypical leg pain rather than the typical intermittent claudication, and even patients without pain often face significant functional limitations (Derbas et al., 2021; Klink et al., 2017; Lim et al., 2017). The occurrence of PAD in all countries is heavily influenced by traditional cardiovascular risk factors such as smoking, hypertension, diabetes mellitus, and dyslipidaemia, as well as the aging of the population (Park et al., 2021; Yan et al., 2020). In low-income and middle-income countries, additional environmental factors like poverty, industrialization, and infection may contribute to the risk of developing PAD (Shu & Santulli, 2018). This condition adversely affects the overall quality of life and is strongly associated with a substantially heightened risk of major cardiovascular events and mortality. It is crucial to recognize that PAD is a significant contributor to amputation cases worldwide (Thiruvoipati, 2015).

Over 170 million people worldwide have diabetes mellitus (DM), and the worldwide burden is projected to increase to 366 million people by 2030. The major causes of DM include impaired insulin secretion or inadequate response to secreted insulin. DM is a major risk factor for atherosclerotic disease as well as cardiovascular mortality and morbidity. Atherosclerotic disease is increased in incidence and its course is accelerated in diabetic patients. Diabetic associated atherosclerosis can lead to complications in all major vascular beds, including the coronary arteries, carotid vessels, and lower extremity arteries. Peripheral vascular disease causes significant long-term disability in diabetic patients, treatment can therefore be expensive, owing to need for a variety of diagnostic tests, therapeutic procedures, and hospitalizations. This can lead to limb amputations (Thiruvoipati, 2015).

Diabetes mellitus has been identified as an established risk factor for cardiovascular disease (Assaad-Khalil et al., 2015; Chin & Sumpio, 2014a;

Thiruvoipati, 2015). The underlying mechanism is believed to involve neuropathy. When patients suffer from both diabetes and peripheral artery disease (PAD), their lower extremity function tends to be more compromised compared to individuals with PAD alone (Al-Delaimy et al., 2004; Chung et al., 2017; Lin et al., 2014). This can be attributed to the combined effects of these two conditions. Additionally, individuals who have the dual diagnosis of diabetes and PAD face a greater risk than PAD patients without diabetes in terms of the accelerated progression of their PAD and the susceptibility to developing coronary artery disease (Ellis et al., 2017; Opolski et al., 2015). The coexistence of diabetes and PAD exacerbates the negative outcomes associated with each condition individually, leading to worse lower extremity function and an increased likelihood of rapid PAD progression and coronary artery disease development (Azzalini et al., 2022).

Numerous epidemiological studies have demonstrated the connection between diabetes and the risk of both asymptomatic and symptomatic Peripheral Artery Disease (PAD), including cases with unconventional symptoms (Criqui et al., 2021; Thiruvoipati, 2015). Patients with diabetes are approximately twice as likely to experience intermittent claudication compared to individuals without diabetes. Moreover, the severity of diabetes plays a role in elevating the risks of PAD: for every 1% increase in the level of haemoglobin A1c, there is a 26% increase in the likelihood of developing PAD (Normahani et al., 2022). Additionally, the duration of diabetes and the use of insulin are associated with a higher risk of PAD. The relative risks of Critical Limb Ischemia (CLI) in individuals with diabetes are considerably greater than those of intermittent claudication (Đurović Sarajlić et al., 2019; Iglesias & Peña, 2014). In fact, the risk of major amputation is about five times higher in diabetic patients compared to those without diabetes. This discrepancy is likely due to sensory neuropathy, microangiopathy, and infection associated with diabetes, as well as a distinct pattern of PAD that affects more distal arteries, which are less amenable to revascularization procedures. With the worldwide diabetes epidemic and escalating obesity levels, an increasing proportion of PAD cases are expected to be diabetes-related, particularly in Western countries where cigarette consumption is declining (Todoran et al., 2012a).

Patients with HIV infection tend to have a high prevalence of cardiovascular risk factors. HIV status has also been associated independently with other manifestations of atherosclerosis including PAD (Dodd & Leipsic, 2020). In a comparison of 540 patients with HIV infection and 524 controls in the Netherlands, PAD was found in 2.6% of patients and 0.6% of controls (Normahani et al., 2022). The association between HIV and all cardiovascular and metabolic diseases in that study was independent of age and smoking (Fowkes et al., 2017).

In a study conducted in Egypt on the use of multi-slice CTA in identification and classification of aorto-iliac diseases found prevalence of atherosclerosis varying small plaques to occlusion (Gamal El Dein et al., 2019; Osama et al., 2012). Hypertension and diabetes mellitus were the most risk factors. The most common symptoms were lower limb claudication and burning pain (Assaad-Khalil et al., 2015). Most aneurysms seen are infra-renal. They concluded that MSCTA is an excellent non-invasive scanning technique for patients suspected of having aorto-iliac occlusive disease, with higher spatial resolution and faster acquisition times, allowing assessment of the aorta and its branches with greater accuracy than other modalities (Alarabawy, El Ahwal, Elwagih, Ismail, & Khattab, 2016).

Numerous studies have extensively investigated conventional risk factors associated with cardiovascular diseases, including smoking, diabetes, dyslipidaemia, and hypertension, along with diverse metabolic and inflammatory factors. These investigations aim to explore the correlation between these factors and peripheral artery disease (PAD) in Western countries. (Lin et al., 2014; Pomposelli, 2010; Willigendael et al., 2005). For over a century, cigarette smoking has been recognized as a significant risk factor for PAD, and numerous studies consistently demonstrate a robust association between smoking and all types of peripheral arterial disease (Assaad-Khalil et al., 2015; Yeh et al., 2022). Quitting smoking is linked to a decreased risk of PAD; however, it may take more than 20 years of cessation to reach the risk level comparable to that of individuals who have never smoked.

Most epidemiological studies have linked hypertension to an elevated risk of peripheral arterial disease (PAD), although the strength of this relationship is not as pronounced as that of smoking or diabetes (Criqui et al., 2021). Assessing the precise impact of high blood pressure as a risk factor is challenging due to the possibility that increased pressure in the legs could potentially counteract the onset of claudication (Axley et al., 2020; Connors et al., 2011). Additionally, there is a growing acknowledgement of hypertension as a risk element in low- and middle-income nations (LMICs), especially in West Africa, and it can substantially contribute to the progression of PAD. Among all the conventional cardiovascular risk factors, smoking and diabetes demonstrate the most robust and consistent connections with a heightened likelihood of developing PAD. (Willigendael et al., 2005). The importance of these risk factors highlights that cardiovascular prevention programs can not only benefit coronary heart disease and stroke but also yield positive outcomes for peripheral artery disease, emphasizing the interconnectivity between them.

Diabetes is linked to a higher likelihood of cardiovascular disease (CVD), particularly when accompanied by hypertension. The risk is amplified when both conditions are present. Diabetes is associated with the development of both macrovascular disease, which affects larger arteries like conduit vessels, and microvascular disease, which affects smaller arteries and capillaries. These chronic conditions impact both the larger and smaller blood vessels in the body (Chin & Sumpio, 2014b).

Research conducted on a group of 30 patients revealed that MSCTA (Multi-Slice Computed Tomography Angiography) outperforms doppler ultrasound when it comes to identifying occlusion, measuring the length of stenosis and calcification, as well as illustrating the disease's extent from the abdominal aorta to the arteries of the feet. These findings are significant in facilitating treatment planning (Chidambaram et al., 2016; Sarkar et al., 2021a). They concluded that doppler ultrasound can detect the lesions to a comparable extent when no intervention is planned and only medical therapy is considered (Shirol et al., 2015).

Sub-Saharan Africa countries are undergoing an epidemiological transition resulting in an increasing incidence of cardiovascular disease (Joseph & Ebenezer, 2020). A study done in southwest Nigeria in diabetic patients showed the overall prevalence of Peripheral arterial disease to be as high as 52.5%. A study in south Africa in 2007 showed the prevalence of peripheral vascular disease is as high as 29% in rural black South Africans (Kumar Paul et al., 2007).

Another study done at Kenyatta National Hospital on PAD in chronic kidney disease patients showed a prevalence of 11.9%, another established that rheumatoid arthritis was found to be significantly associated with the likelihood of having peripheral arterial disease (Khodary et al., 2015). A study done in 2004 at Kenyatta National Hospital by Awori also found Peripheral arterial disease to be the main indication for lower limb amputations 55.3% of which 37.8% were not diabetic (Mehta et al., 2017). Majority of these patients were 31-45 years.

Cardiovascular Disease Burden in Peripheral Arterial Disease has shown that patients are at an increased risk for cardiovascular events, similar to or greater than in patients with coronary artery disease. A study that was done at the Kenyatta National Hospital (Kaguthi, 2009) among 73 scheduled for multidetector CTA, it was reported that 46.6% of the participants had PAD of the lower limb.

Chronic peripheral arterial disease of the lower limbs affect three distinct segments, the aortoiliac, femoropopliteal and peroneotibial segments. Only patients with diabetes mellitus or thromboangitis obliterans develop disease in the peroneotibial segment. Claudication is caused by disease of a single segment, limb pain and limb threatening ischaemia is caused by disease of multiple segments (Knepper & Henke, 2013). Signs that increase the probability of PAD are absence of both pedal pulses or femoral pulses, presence of wounds or sores, asymmetric limb coolness and presence of a limb bruit (Disease, n.d.). Lower limb atherosclerosis is a marker for systemic artherosclerosis in patients with morbidities (Shirol et al., 2015).

Limited information is currently accessible regarding the advancement of leg disease in patients with Peripheral Arterial Disease (PAD) who have a low Ankle-Brachial Index (ABI) and experience atypical leg pain (Aboyans et al., 2012;

Criqui et al., 2010). Within the scope of the Walking and Leg Circulation Study, individuals falling into various symptom categories were monitored for a period of 2 years, followed by an additional 7 years, in order to evaluate the rate of functional deterioration. The study revealed that patients with PAD who initially experienced leg pain during physical activity as well as at rest demonstrated a greater decline in mobility after 2 years compared to those without PAD. Furthermore, after 7 years, they exhibited a more substantial decline in mobility compared to patients with claudication.

It is challenging to provide an accurate description of the natural progression of extremely severe symptomatic peripheral arterial disease (PAD) due to various treatment approaches such as revascularization, primary amputation, or medical intervention, as well as limited survival rates among affected patients (Kulezic et al., 2022; Saphir et al., 2021). The specific treatment methods employed differ significantly among healthcare centres, but in Western countries, approximately half of individuals experiencing critical limb ischemia (CLI) undergo some form of revascularization, with certain specialized centres reporting rates as high as 90% (Farber, 2018; Romiti et al., 2008).

Quality of life (QOL) in individuals with claudication, a condition characterized by pain in the legs during exercise, has been found to be inferior compared to that of healthy individuals (Ahimastos et al., 2013; Zhao et al., 2022). This decline in QOL primarily relates to physical functioning rather than mental well-being. Interestingly, the impact on QOL in claudication patients is similar to that experienced by individuals with angina, a condition caused by reduced blood flow to the heart (Zhao et al., 2022). A comprehensive survey conducted in the USA, encompassing both symptomatic and asymptomatic peripheral artery disease

(PAD), revealed that the burden on QOL is comparable to other cardiovascular diseases. Furthermore, patients with critical limb ischemia (CLI), a severe form of PAD, experience even worse QOL than those with intermittent claudication, particularly due to the significant suffering and distress caused by pain. In fact, the QOL of CLI patients is similar to that of individuals seriously ill with cancer. For CLI patients who are not suitable candidates for surgery or angioplasty, their QOL scores are consistently lower than the average scores of the general population across all health dimensions, with the most significant impact on physical functioning and bodily pain.

In an analysis of subsequent investigations, it was observed that approximately 20% of individuals diagnosed with claudication experienced notable decline within a span of five years. Among those who experienced deterioration during this initial period, roughly two-thirds displayed worsened symptoms of claudication, while up to one-third developed critical limb ischemia (CLI). It is worth noting that less than 5% of all claudication patients required amputation.

### 2.2 Anatomical basis of Peripheral vascular disease of the lower limbs

The anatomic coverage for a lower extremity CTA typically extends from vertebral level T12 through to the toes, with a 25–30-cm field of view, to provide adequate in-plane resolution (Rubin, 2014). Knowledge of the lower limb arterial anatomy is necessary to better understand the disease process and improve patient assessment and management.  Typically, the abdominal aorta divides into the two common iliac arteries at the level of the fourth lumbar vertebra (Laswed et al., 2008). The common iliac arteries further divide into the internal and external iliac arteries. The external iliac artery becomes the common femoral artery where it crosses under the inguinal ligament midway between the anterior superior iliac spine and the pubic symphysis. The common femoral artery has three superficial branches at this point: superficial circumflex iliac artery, superficial inferior epigastric artery, and the superficial pudendal artery (Itoga et al., 2017b). The profunda femoris artery arises 5cm distal to the inguinal ligament and has six branches: medial and lateral circumflex femoral arteries and four perforating arteries (Klein et al., 2014). The lateral circumflex femoral artery has an ascending branch that anastomoses with a branch of the superior gluteal artery, and it also sends a descending branch to the knee (Soga et al., 2012). It can provide a route of collateral supply capable of bypassing an obstructed superficial femoral artery (Itoga et al., 2017). The four perforating arteries supply the muscles of the thigh and surround the femur on angiography (Collins et al., 2007). The femoral artery continues as the superficial femoral artery and has few branches in the thigh. At the junction of the upper two-thirds and the lower third of the femur it passes through the adductor hiatus close to the femur and into the popliteal fossa to become the popliteal artery. Just before this it supplies a descending branch to the genicular anastomosis. Popliteal artery supplies branches to the genicular anastomosis, branches to the knee joint and divides at the lower border of the knee joint into anterior and posterior tibial arteries (Lee et al., 2019). The posterior tibial artery is the larger of the two terminal branches, it gives rise to the peroneal artery 2.5 cm from its origin and its supplies branches to the genicular anastomosis, the muscles, skin and tibia (Narang & Budoff, 2023). At the ankle it supplies a medial malleolar branch to the ankle anastomosis and then passes posterior to the medial malleolus to divide into the medial and lateral plantar arteries, the principal supply to the foot.

The peroneal artery, as it descends, comes to lie close to the medial aspect of the posterior of the fibula (Garvey et al., 2012; Knitschke et al., 2021). It runs behind the distal tibiofibular joint and ends as calcaneal branches supplying the superior and lateral aspects of that bone. Its other branches include muscular branches, nutrient artery to the fibula, perforating branch, communicating branch (joins similar branch from the posterior tibial artery). The anterior tibial artery arises from the popliteal artery, passes above the upper margin of the interosseous membrane and descends anterior to this membrane until it becomes superficial at the ankle midway between the malleoli. Dorsalis pedis artery is a continuation of the anterior tibial artery and supply the arcuate artery for the metatarsal and digital arteries, passes between the first and second metatarsals to join the plantar arch (Bonvini et al., 2011).

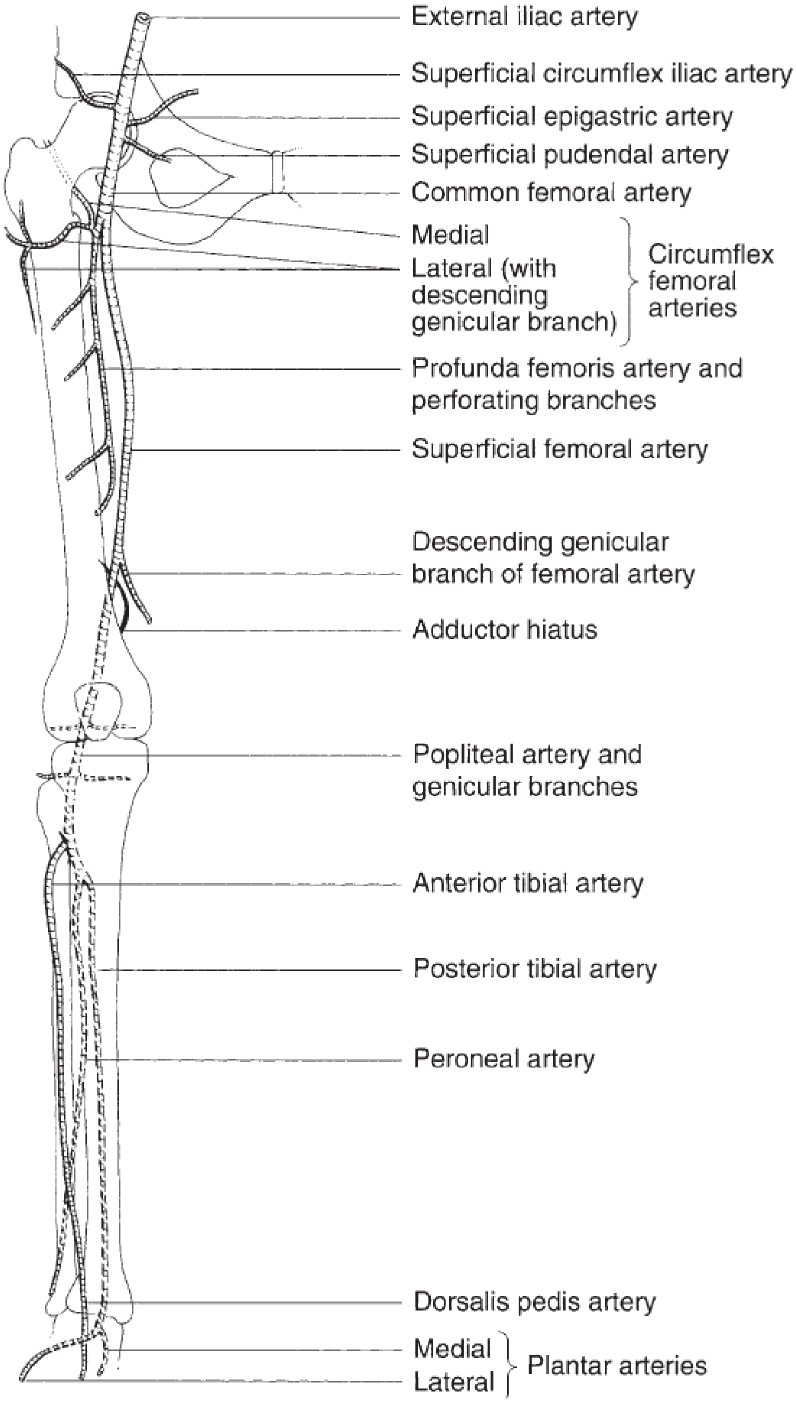


**Figure 1: Arteries of the lower limbs**

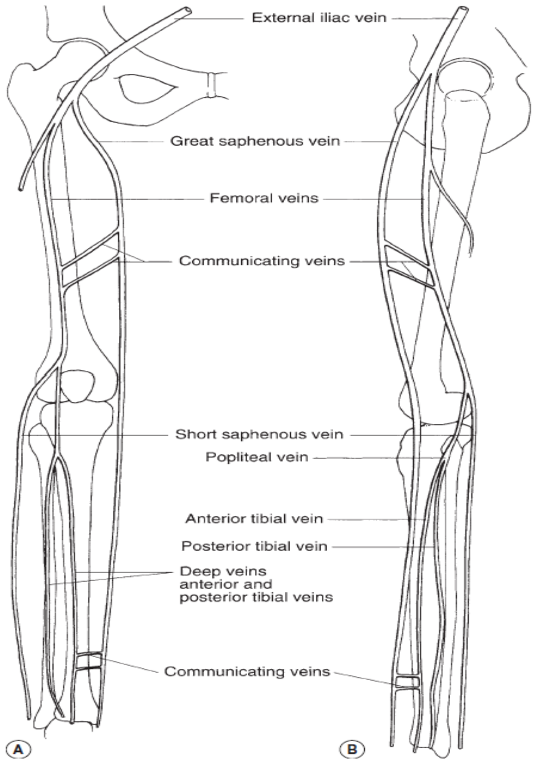


**Figure 2: Veins of the lower limbs**

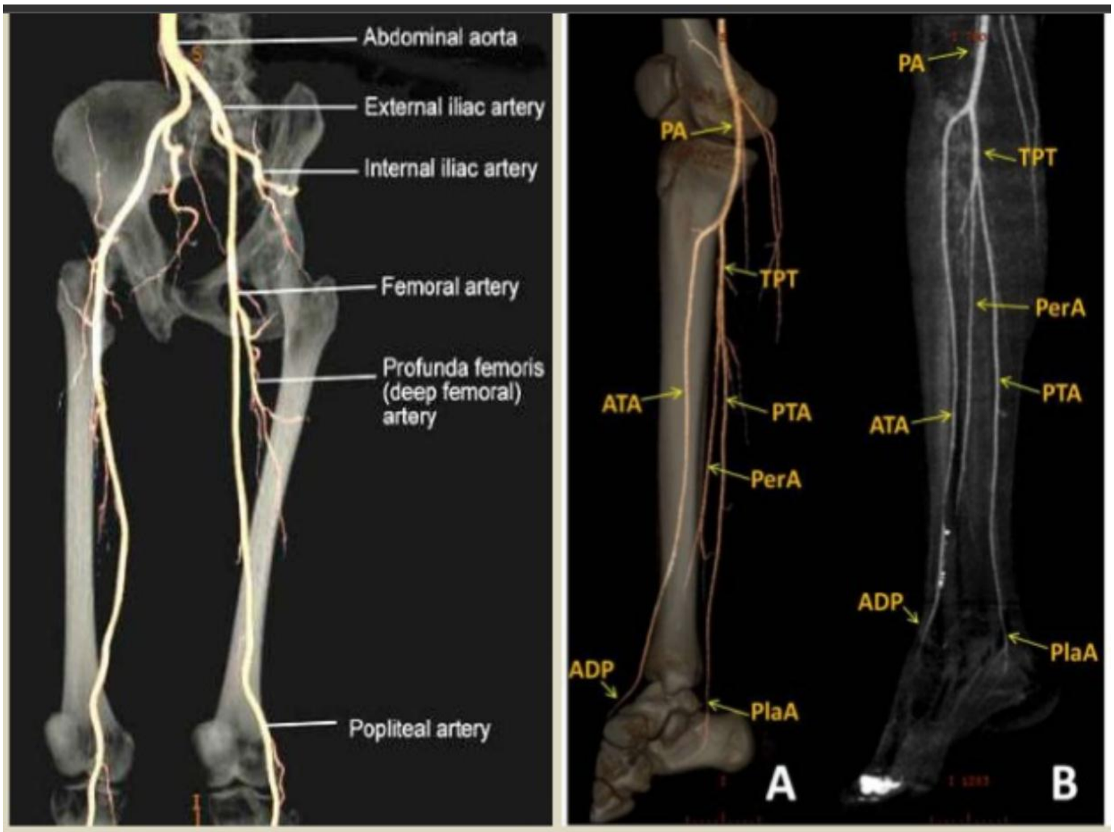


**Figure 3: Arteries of the lower limb as seen on CTA.**

Superficial veins are the long and short saphenous veins. long saphenous vein starts on the medial side of the dorsum of the foot and passes anterior to the medial malleolus, ascends vertically to lie posterior to the medial side of the knee and anterior to the upper thigh, it receives the anterior femoral cutaneous vein on anterior surface of the thigh. It drains into the femoral vein via the saphenous opening in the lower part of the inguinal canal.

Short saphenous vein begins on the lateral side of the dorsum of the foot, passes posterior to the lateral malleolus, ascends on the back of the calf to enter the popliteal vein. Deep veins of the lower limb accompany the arteries, usually paired. Although more than one vein may accompany one artery. Perforating or communicating veins carry blood from superficial veins to the deep veins and are variable in site and number (Gloviczki et al., 2011).

**2.3 Indications for CTA**

A single study using CTA enables the evaluation of peripheral artery disease (PAD) spanning from the abdomen to the feet. By examining lesion length, location, and vascular morphology, the CTA assessment facilitates the determination of disease burden. This valuable information aids the operator in devising an intervention plan, including patient positioning, access site selection, and treatment approach (Itoga et al., 2017a; Ofer, Nitecki, et al., 2003; Sibley et al., 2017).

Patients diagnosed with peripheral vascular diseases affecting the lower limbs frequently experience a lack of symptoms, with estimates ranging from 50% to 80%. They may either be asymptomatic or present with indistinct, atypical leg pain. This absence of symptomatology in individuals suffering from occlusive arterial disease in the lower extremities can be attributed to both physiological adaptation and anatomical constraints (Natha et al., 2014). Multiple studies have reported that the major risk factors for peripheral vascular diseases of the lower limb include being older than 50 years (Mehta, 2016), a history of diabetes and hypertension (either alone or combined), a history of chronic heavy smoking (Osama et al., 2012) and dyslipidemia (Mehta, 2016). Diabetes, cardiac disease and being of an advanced age have been considered as independent predictors of vessel wall calcification (Meyersohn et al., 2015). Specifically, diabetic patients with an infrapopliteal disease were more likely to present with chronic lower limb ischemia compared to non-diabetic patients (Sayed et al., 2016). These observed arterial lesions are classified as either normal, mild, or marked stenosis as well as occlusion of the lumen in the affected vessel (Sayed et al., 2016). On the other hand, chronic venous insufficiency occurs alongside unrestrained ambulatory venous hypertension that is associated with venous wall and valve incompetence (Shabani Varaki et al., 2018). These hypertensive patients are further at risk of developing deep vein thrombosis that occurs with the formation of a blood clot in the deep venous system commonly of the lower limbs such as the superficial femoral and popliteal veins in the thigh and the posterior tibial and peroneal veins in the calves (Shabani Varaki et al., 2018).

Peripheral arterial disease (PAD) is a prevalent condition commonly found in elderly individuals, and it represents a significant contributor to the development of atherosclerotic cardiovascular complications. This condition's impact on morbidity cannot be understated. One valuable diagnostic tool for detecting PAD, assessing the severity of atherosclerosis, and formulating an appropriate treatment plan is lower extremity CT angiography (LE-CTA). By utilizing LE-CTA, healthcare professionals can effectively identify the presence of PAD, analyze anatomic variations, evaluate limb ischemia, and determine the optimal placement of stents if necessary. In terms of detecting PAD, LE-CTA has proven to be a valuable method. It not only aids in identifying the existence of this condition but also provides essential insights into the anatomic variations that may be present, as well as the extent of limb ischemia. By leveraging LE-CTA, medical practitioners can gather crucial information about the severity of arterial stenosis, facilitating the development of appropriate treatment strategies. Guidelines established by medical experts presently endorse the utilization of LE-CTA examinations as a means to assess PAD and determine the severity of arterial stenosis. Furthermore, LE-CTA plays a vital role in guiding treatment planning. This advanced imaging technique allows healthcare professionals to accurately pinpoint the exact location and extent of atherosclerosis, thereby aiding in the decision-making process concerning endovascular therapy or surgical intervention. By incorporating LE-CTA into the diagnostic process, medical professionals can effectively evaluate the appropriateness of endovascular therapy or surgical procedures for patients with PAD. LE-CTA's ability to provide precise information about the precise location and extent of atherosclerosis enables healthcare providers to make well-informed decisions regarding the most suitable treatment course for each individual case. To summarize, PAD is a prevalent condition that frequently affects elderly patients and stands as a primary cause of atherosclerotic cardiovascular morbidity. When it comes to detecting PAD, evaluating anatomic variations, assessing limb ischemia, and planning treatment, lower extremity CT angiography (LE-CTA) proves to be an invaluable tool. Current guidelines advocate for the use of LE-CTA examinations to assess the severity of arterial stenosis, determine treatment options, and make informed decisions regarding the appropriateness of endovascular therapy or surgery based on the precise location and extent of atherosclerosis.(Preuß et al., 2016a)

These chronic disease patients could also present with intermittent claudication, associated rest pain while some may be diagnosed with limb gangrene (Osama et al., 2012). Previous long surgeries could also increase the risk for deep vein thrombosis of the lower limbs (Osama et al., 2012). On angiography, infrarenal saccular aneurysms, ileal mycotic aneurysm as well as arterial tree distal aneurysm have been noted (Osama et al., 2012). Previous studies (Fleischmann et al., 2006; Met et al., 2009; Syed et al., 2019) have also reported vessel stenosis or arterial occlusion, intermittent critical limb ischemia and distal disease in the presence of arterial wall calcification. Therefore, computerized tomography angiography (CTA) aids in the visualization of distally reformed artery in the same image as the proximal vessel among patients with long-segment occlusion (Mishra et al., 2017). This study will therefore determine the common clinical diagnosis of the patients with peripheral vascular diseases of the lower limb at a teaching hospital in Western Kenya.

There are two significant reasons why the diagnosis of PAD should not be disregarded. Firstly, individuals with PAD may encounter various complications, including claudication, ischemic rest pain, ischemic ulcerations, frequent hospitalizations, revascularizations, and potential limb loss (Sarkar et al., 2021b). Run-off CTA provides a dependable imaging technique for the initial evaluation of individuals with acute and chronic peripheral artery disease (PAD) (Werncke et al., 2015).

In the past, the evaluation of PAD before treatment usually involved the use of conventional catheter angiography. Nevertheless, this procedure is invasive and carries certain risks, including complications at the puncture site and issues related to the catheter, with a potential complication rate as high as 10%. The emergence of alternative minimally invasive techniques, such as multidetector computed tomographic (CT) angiography and contrast material-enhanced magnetic resonance (MR) angiography, has significantly decreased the requirement for diagnostic catheterization. These advanced procedures, ranging from CT angiography to MR angiography with contrast enhancement, have effectively diminished the necessity for invasive catheter-based diagnostic approaches (Napoli et al., 2011).

### 2.3.1 Pathology of Atherosclerosis

The most common cause of PVD is usually secondary to stenotic or occlusive atherosclerosis. Atherosclerosis is a systemic disease. The prevalence of symptomatic disease is approximately 5% at the age of 60 years and increases with age (Owen & Roditi, 2011). Atherosclerosis is a condition characterized by the build-up of plaque in the arteries and is the primary underlying factor contributing to cardiovascular disease, a leading cause of death globally (Syed et al., 2019).

The presence of polyvascular atherosclerosis, where multiple territories in the body are affected by arterial lesions, has been linked to an increased risk of developing future cardiovascular disorders (Alarabawy et al., 2016). Atherosclerosis also causes intimal calcification (Lin et al., 2014; Riffel et al., 2018).

Risk factors associated with atherosclerotic PAD are smoking, diabetes, age, elevated C-reactive protein, chronic renal insufficiency, dyslipidemia, and hypertension (Mehta et al., 2017; Smith et al., 2004). Hypertension is a significant determinant in the development of atherosclerosis, as stated by research. Hypertension raises filtration pressure and enhances endothelial permeability (Hoeper et al., 2023). This condition not only expedites the progression of atherogenesis but also leads to deteriorative alterations in the walls of large and medium arteries, increasing the likelihood of aortic aneurysms and dissection (Park et al., 2021). Additionally, diabetes plays a particularly crucial role as a risk factor due to its frequent association with severe peripheral arterial disease (Pan et al., 2022).

Clinical presentations include asymptomatic which is the most common, intermittent claudication which is reproducible pain in the lower limb with exertion that resolves quickly with rest, critical limb ischemia which is chronic ischemia that causes either rest pain or wounds, acute limb ischemia which is a sudden decrease in limb perfusion (Knepper & Henke, 2013). Around 10% of people with PAD report symptoms of intermittent claudication (IC), around half report leg symptoms other than IC, 40% report no symptoms. PAD can increase the risk of infection in the affected area with severe occlusion increasing the risk of gangrene (G. Wu et al., 2016) and amputation (Saphir et al., 2021).

The great advantage of CTA remains the visualization of calcifications, clips, stents, and bypasses (Kang et al., 2016). However, some artefacts may be present due to the 'blooming effect' (Bui et al., 2005). The interpretive objectives in evaluating atherosclerosis are to recognize and characterize levels of luminal patency, obstructive stenosis, and occlusion. When obstructive disease is detected, there is need to define the presence and extent of collateral pathways (Gerhard-Herman et al., 2017).

Three-dimensional (3D) volume rendering (VR) and maximum intensity projections (MIP) provide an understanding of the spatial relationships and global arterial anatomy in a circulatory territory. Structural detail is interrogated using 2D multiplanar (MPR) and curved planar (CPR) reformations Orthogonal views should be generated to precisely grade the severity of luminal stenosis, characterize atherosclerotic plaque, and confirm the presence of ulcerations.

Acute Limb Ischemia (ALI) is a critical medical condition that demands urgent intervention to preserve the affected limb, and it has recently gained significant recognition as a noteworthy complication of Peripheral Artery Disease (PAD). ALI typically manifests as a sudden or rapid decline in blood supply to the leg, resulting in symptoms such as severe pain, absence of pulse, paleness, loss of sensation, or even paralysis. It is crucial to address ALI promptly due to the severity of its impact on limb perfusion. The occurrence of ALI and major lower extremity amputations (commonly defined as amputations at or above the ankle) is often categorized as significant adverse events affecting the limbs. While amputation may be viewed as a complication, it should be acknowledged as a vital treatment option aimed at preserving both lives and proximal limbs. By opting for amputation, when necessary, healthcare professionals can effectively safeguard the well-being of patients and retain functionality in the remaining portions of the affected limb (Horehledova et al., 2018).

The actual prevalence of ALI remains largely uncertain due to the diverse ways it manifests and is managed. Often, research studies encompass both ALI and chronic limb ischemia, lacking distinct discrimination between the two conditions. Unusual factors contributing to the onset of acute limb ischemia consist of Vasculitis, Popliteal entrapment syndrome, Paradoxical embolism, Acute compartment syndrome, Foreign body embolization, Thrombophilia, and Low cardiac output syndromes (Björck et al., 2020).

The natural progression of intermittent claudication (IC) indicates that only 25% of patients will experience a deterioration in their claudication symptoms.1 One of the most concerning complications associated with peripheral arterial disease is the advancement to major limb amputation (Budge et al., 2016). Historically, individuals with IC have been reported to have an incidence of approximately 1-3% for this devastating outcome within 5 years of the initial diagnosis. Considering the low likelihood of amputation, interventions for IC are generally not aimed at preventing amputation but rather to provide relief from symptomatic discomfort. Consequently, interventions are typically reserved for patients who do not respond to initial treatments such as risk factor modification and medical therapy (Axley et al., 2020c).

Patients diagnosed with critical limb ischemia exhibit elevated mortality and amputation rates following revascularization procedures when compared to patients suffering from intermittent claudication. The development of critical limb ischemia typically arises from severe atherosclerosis affecting the arteries in the lower extremities, combined with a disruption in skin integrity. In the modern treatment of critical limb ischemia, surgical or endovascular revascularization approaches are commonly employed due to the substantial risk of limb loss associated with relying solely on medical therapy. Endovascular therapy has emerged as the preferred initial treatment for critical limb ischemia, offering numerous advantages over surgical bypass procedures (Todoran et al., 2012b).

Chronic limb-threatening ischemia (CLTI) is linked to death, the need for amputation, and a decrease in quality of life. CLTI is a medical condition characterized by the coexistence of peripheral artery disease (PAD) along with symptoms such as persistent pain at rest, tissue decay (gangrene), or the presence of a lower limb ulcer lasting more than two weeks (Conte et al., 2019).

### 2.3.4 Pathology of vascular trauma

Arterial trauma can result from both penetrating, blunt trauma and iatrogenic injury. CTA findings seen after arterial injury can be categorized as either direct or indirect. Indirect signs include perivascular hematoma, injury tract from penetrating trauma and shrapnel less than 5mm away from an artery (Lee et al., 2019). The evident indications observed on the CTA involve dynamic leakage of contrast material, the development of pseudoaneurysms, constriction of arterial lumens in specific segments, alterations in the contour or trajectory of blood vessels, damage to the inner layer of arteries known as intimal dissection, and early filling of veins due to the presence of arteriovenous fistulas (Oweis et al., 2017).

Arterial thrombosis has the potential to develop at the location of an injury, arising from either partial harm to the vascular wall or complete disruption of the blood vessel. By employing computed tomography angiography (CTA) for examination, a non-obstructive blood clot can be identified as a noticeable abnormality within the vessel's interior. CTA findings in instances of occlusive thrombosis unveil an abrupt interruption in the contrast material's flow within the affected artery, with the length of this interruption varying (Oweis et al., 2017).

**Table 2. 1: Femoral popliteal lesions as per TASC II classification.**

| | |
|---|---|
| Type A lesions | Single stenosis of ≤10cm in length or a single occlusion≤5cm in length. |
| Type B lesions | Multiple lesions, each ≤5cm or single lesion ≤15cm not involving the popliteal artery.<br>Heavily calcified occlusion ≤5cm.<br>Single popliteal stenosis. |
| Type C lesions | Multiple lesions totalling ≥15cm regardless of calcification or recurrent lesions that require treatment after two endovascular interventions. |
| Type D lesions | CFA or SFA CTOs $> 20cm$ involving the popliteal or CTO of the popliteal and proximal trifurcation. |

## 2.4 Computerized Tomography Angiography

This study investigates the arrangement of various blood vessels and their sections in the abdomen, pelvis, thigh, and calf. These areas are commonly assessed using Computerized Tomography Angiography (CTA). Multiple research studies have explored the vascular irregularities observed on CTA and classified them into three main categories: aneurysms, occlusions, and stenosis. Additionally, these abnormalities have been further subdivided to enhance comprehension and knowledge in this field.(Fleischmann et al., 2006; Fleischmann & Rubin, 2005). In a study conducted in the United States of America (Huang et al., 2012), the authors enrolled 230 participants and compared abdominopelvic, thigh and calf distribution of various vessels. The most common abdominopelvic findings were in the external iliac artery (n = 34), followed by common iliac artery (n = 29) and Infrarenal aorta (n = 15). The most frequently reported thigh distribution was common femoral artery (n = 34) followed by superficial femoral artery (n=27), profunda femoral artery (n=25) and popliteal artery (n=20). On the calf (Huang et al., 2012), the authors reported tibioperoneal trunk (n=14) followed by peroneal artery (n=12), anterior tibial artery (n=11) and posterior tibial artery (n=9). These findings are similar to those reported in China (Duan et al., 2013) where CTA was found to have 100% sensitivity for assessing derangements in the calf distribution compared to DSA. Other studies reported derangement in different vessel segments. In India (Mishra et al., 2017), among the 63 participants enrolled, the most common CTA finding was in the aortoiliac segment (n=22), followed by femoropopliteal (n=16) and infrapopliteal artery (n=15). In Sweden (Swanberg et al., 2014) the most common vessel segment derangement was infrapopliteal arterial lesion among 6 of the 10 patients who underwent CTA.

In the Netherlands, the sensitivity of CTA in comparison to DSA in the identification of normal vessel segments and those with either stenosis or occlusion was 96%, 89% and 94% respectively (Jens et al., 2013). In a study conducted in Israel (Ofer et al., 2003), the sensitivity of CTA in determining 50% occlusion of vessels of the lower limbs was 91% compared to DSA. However, no sensitivity data was provided for occlusion (Ofer, Linn, et al., 2003). In Canada (Martin et al., 2003), CTA had a 92% sensitivity for detecting 75% stenosis when compared to DSA while the sensitivity for CTA detecting occlusion was at 89%. In a study conducted in Japan, the authors (Otal et al., 2004) found a 99% sensitivity of CTA detecting 50% vessel stenosis compared to DSA. The sensitivity of CTA detecting stenosis in the iliac and femoral vessels was 99% and 100% respectively (Otal et al., 2004). Similarly in Italy (Fraioli et al., 2006), the sensitivity of CTA in the detection of 50% steno-occlusion was found to be 96% compared to DSA, specifically for aortoiliac, femoral and popliteocrural vessels the sensitivity was reported at 95%, 98% and 96% respectively. In Austria (Portugaller et al., 2004) the sensitivity of CTA for detecting 50% steno-occlusion was set at 92%, while for aortoiliac and femoropopliteal vessels was 92% and 98% respectively; while in the United Kingdom (Edwards et al., 2005) the sensitivity for detecting 50% stenosis was 79% and 75% of occlusion. This trend has also been seen in Switzerland (Willmann et al., 2005) where the sensitivity for detecting 50% steno-occlusion was 96%. Sensitivity for CTA detecting derangement in aortoiliac, femoral and politeocrural vessels was 95%, 98% and 96% respectively (Willmann et al., 2005).

Computed tomography angiography (CTA) is a recognized and efficient technique used to assess the cardiovascular system. A noteworthy benefit of CTA is its capacity to offer a complete depiction of the entire vessel, from its source to the target structure. This advantage remains significant even when vessels exhibit convoluted or intricate anatomical characteristics. CTA has emerged as a reliable and effective means of evaluating the cardiovascular system, providing detailed visualization of vessels throughout their entirety.

CTA utilizes non-invasive methods to accurately detect unfavorable plaque attributes and offer significant information about the structure of plaque. This feature empowers medical professionals to evaluate the makeup and durability of the plaque, facilitating the prediction of potential cardiovascular incidents. Moreover, CTA's exceptional spatial resolution enables the identification of specific narrowing within the arterial lumen, assisting in the diagnosis and assessment of conditions like coronary artery disease.(Tanaka et al., 2019).

In addition to its proficiency in assessing plaque characteristics, CTA is also highly suitable for visualizing vessel calcification. The ability to accurately detect and quantify calcified deposits within the vessel walls is crucial in diagnosing and monitoring the progression of atherosclerosis, a common underlying cause of Moreover, CTA allows for the evaluation of the hemodynamic significance of stenotic lesions. By assessing the degree of stenosis and measuring the blood flow through the affected vessels, CTA can help determine the need for further intervention, such as coronary revascularization procedures or medical management.

In summary, CTA has solidified its position as a valuable imaging technique for evaluating the cardiovascular system. Its capacity to observe the complete vessel, recognize unfavorable plaque characteristics, describe plaque structure, identify narrowing of the vessel lumen, and visualize calcification in the vessels renders it an essential instrument for healthcare professionals. By virtue of its non-invasive characteristics, ability to generate three-dimensional representations, and capacity to assess hemodynamics, CTA provides considerable benefits in the diagnosis and guidance of treatment options for individuals afflicted with cardiovascular ailments.

### 2.5 Conceptual Framework

This study hypothesizes that the findings of CTA will influence the resultant intervention a patient with peripheral vascular disease of the lower limbs finally receives. However, the CTA test is dependent on the clinical diagnosis that leads to a request of the test. Therefore, Multi-slice CT Angiography diagnosis is the independent variable of this study while the resultant intervention plan is the dependent variable. The patients' clinical diagnosis is the moderating variable to this direct relationship (Figure 4).

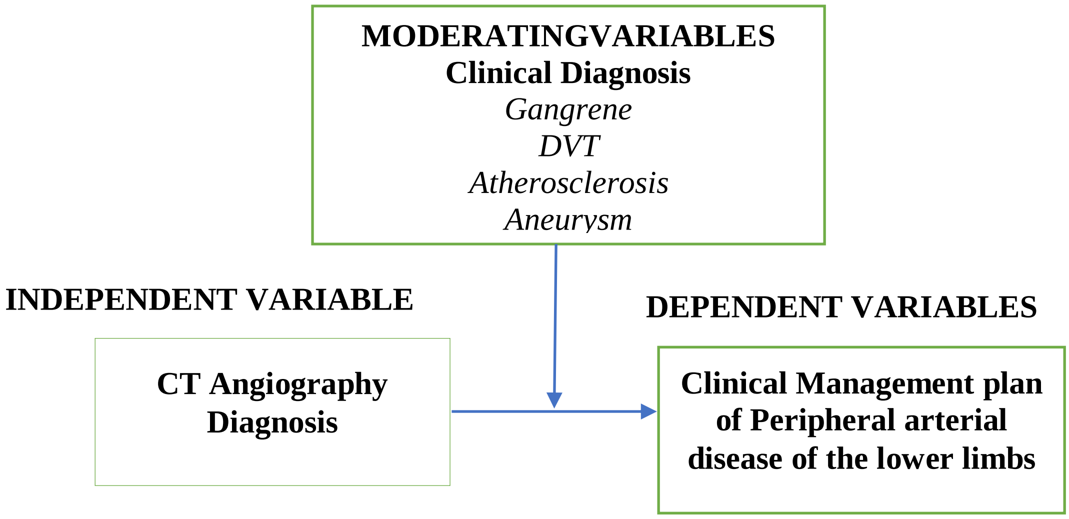


**Figure 4: Conceptual Framework**

# CHAPTER THREE

## 3.0 METHODOLGY

### 3.1 Study Site

The study was conducted at the radiology department of Moi Teaching and Referral Hospital (MTRH). MTRH is located within Eldoret Town, Uasin Gishu County in the North Rift Region of Kenya. It is approximately 320 kilometers northwest of the capital city Nairobi. It has a bed capacity of approximately 800 beds. The radiology unit has the Digital General X-ray unit, The Digital mammography unit, The Fluoroscopy unit, the X-ray reporting unit, The CT scan unit and CT scan reporting unit, The Ultrasound unit and the Magnetic Resonance Imaging unit. The CT scan unit has 3 CT scans of 32, 64, and 128 slices.

### 3.2 Study Design

The study was a hospital based descriptive cross-sectional study conducted over a period of 12 months between October 2021 and September 2022. Patients with peripheral arterial disease of the lower limbs undergoing CTA were recruited into the study.

### 3.3 Study Population

Adult individuals aged 18 years or more referred for computed tomography angiography because of peripheral arterial disease of the lower limbs.

## 3.4 Eligibility Criteria

### 3.4.1 Inclusion criteria

1. Request form for CTA of the lower limbs with a provisional diagnosis of PAD.

### 3.4.2 Exclusion criteria

1. Patients with known hypersensitivity to iodinated contrast media.
2. Patients with kidney failure with creatinine clearance lower than 30ml/min.
3. Patients with lower extremity amputations.

## 3.5 Sampling

### 3.5.1 Sample size determination

This study utilized a cross-sectional study design. Because of the selected design, the most appropriate sample size determination technique was Fischer's formula which is appropriate for hospital-based clinical studies (Hulley, 2013).

$$n = \frac{p(1-p)z^2}{e^2}$$

***Where:***

n=sample size

p= proportion estimated at 4.5% (Bourrier *et al*, 2020)

1-p = 95.5%

e=margin of error (5%)

z=z-value at 95% confidence interval (1.96)

**Substituting:**

$$\frac{0.045(1-0.955)1.96^2}{0.05^2} = 66$$

Therefore, this study enrolled 66 patients with peripheral vascular disease of the lower limbs.

### 3.5.2 Sampling technique

Consecutive sampling technique was used to identify study participants until the desired sample size was achieved.

## 3.6 Study Procedure

The staff and technicians at the CT scan centre and medical doctors based at the emergency department were sensitized about the study. All patients presenting for CTA and who met the inclusion criteria were explained to in a language they well understood the purpose of the examination and about the study. Eligible patients were approached, a written informed consent administered, prior to study enrollment where a unique study number was given. As part of the protocols for CTA, urea and creatinine tests were done as pre-procedural laboratory investigations to rule out acute kidney injury or chronic kidney disease.

Among patients who have previously reacted to contrast media during initial CTA, were ineligible from study presentation. This information was obtained by interviewing the patients prior to patient preparation.

**Patient preparation:** The patient was starved 6 hours prior to imaging, given water to be well hydrated. IV cannulation for contrast administration was put, the patient then changed into a hospital gown.

**Patient positioning:** Patient was positioned supine, near the isocenter of the scanner. For arterial imaging the scan was done headfirst and venous imaging scanning done feet first. CTA scan images were acquired with a helical technique using a Neusoft 128 CT scan machine operated by two radiographers. The CT imaging parameters were tube voltage 120 kVp, reference tube current-time product 250-300 mAs.

Arterial imaging was acquired using the following protocol: using nonionic iodinated contrast 120ml low osmolar contrast media with a chaser of 60 ml of normal saline, contrast was injected at a rate of 2.5 mls/s. the range of scan was from the level of kidneys on the abdominal aorta to heel, slice thickness 3mm or less, reconstruction increment 0.6mm, bolus tracker closer in the suprarenal aorta. For vascular assessment, images were first reconstructed with a slice thickness of 3mm, reconstruction level of 0.6mm. Venous imaging was acquired using the following protocol: a cannular was fixed on each foot, 40ml of contrast with a chaser of 20ml normal saline for each foot at a flow rate of 3.5ml/s and empiric delay of 180 seconds. The imaging began from the toes (feet first) to the level of the kidneys of the abdominal aorta.

The images obtained were pre-contrast, arterial phase, venous phase and delayed. They were coronal and sagittal reformats as well as MIP reconstructions done.

The CTA images were evaluated by two radiologists.

**Participant Follow-up:** Participants medical records were abstracted to obtain information on the treatment plan offered to the patients and further determine if the interventions were informed by CTA findings.

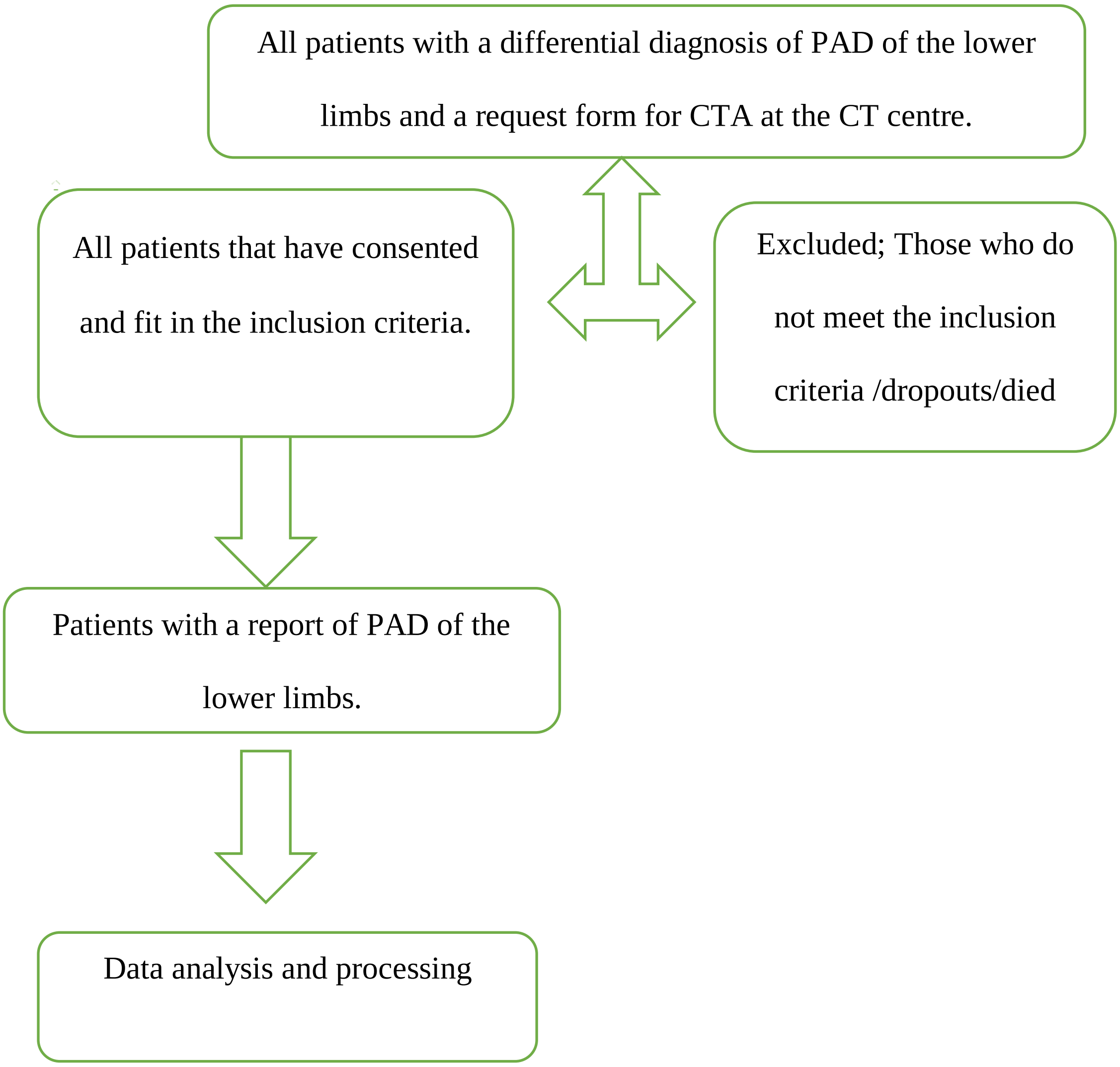


**Figure 3.1: Enrolment flow chart**

### 3.6.1 Data Collection

Data was collected using a data collection form (Appendix II) whereby comprehensive data including patient's age, sex, reason for referral for CTA, and CTA findings were obtained. The imaging findings were recorded after review by two radiologists. Information gathered was then entered into a computer database.

### 3.6.2 Data Analysis

The dataset was then exported to statistical package for social sciences (SPSS) for descriptive and inferential statistical analysis. Fisher's exact test was used to test the association between clinical diagnosis and CTA findings. A test of association comparing the CTA findings and resultant patient management was also conducted using a critical value of $\leq 0.05$. Odds ratios between predictor and outcome variables was computed at 95% confidence interval.

### 3.6.3 Data Quality and Security

Data was double entered into a computer to ensure accuracy. The entry screen included check codes to minimize errors. The computers were password protected and access only allowed for authorized persons. Databases obtained were stored electronically; copies of filled questionnaires were stored in a locked shelf located in the principal investigators residence. Backups for the database were created in remote disks and flash drives and kept in different safe locations to guard against loss of information.

### 3.7 Ethical considerations

Prior to the commencement of the study, ethical approval was sought from Moi University Institutional Research Ethics Committee (IREC) and Permission obtained from the MTRH administration.

A written informed consent form explaining the rationale and benefits of the study to the public health system was used to seek informed consent from potential study participants (Appendix I). Informed consent to participate in the study was obtained from all conscious adult patients.

Participation in the study was on a voluntary basis, the participants were at liberty to withdraw from the study at any stage without being penalized. There were no incentives for participating. The interviews were conducted in a confidential manner; participant names were not recorded. No study participant was identified by name in any report or publication derived from information collected for the study. Data collected was stored in lockable cabinets, databases created were password protected to avoid unauthorized access.

# CHAPTER FOUR

## 4.0 RESULTS

### 4.0 Participant Sociodemographic Characteristics

This study enrolled 66 patients with peripheral arterial disease with a mean age of 63.2 (±16.521) years with the age ranging between 18 to 97 years (Figure 4.1).

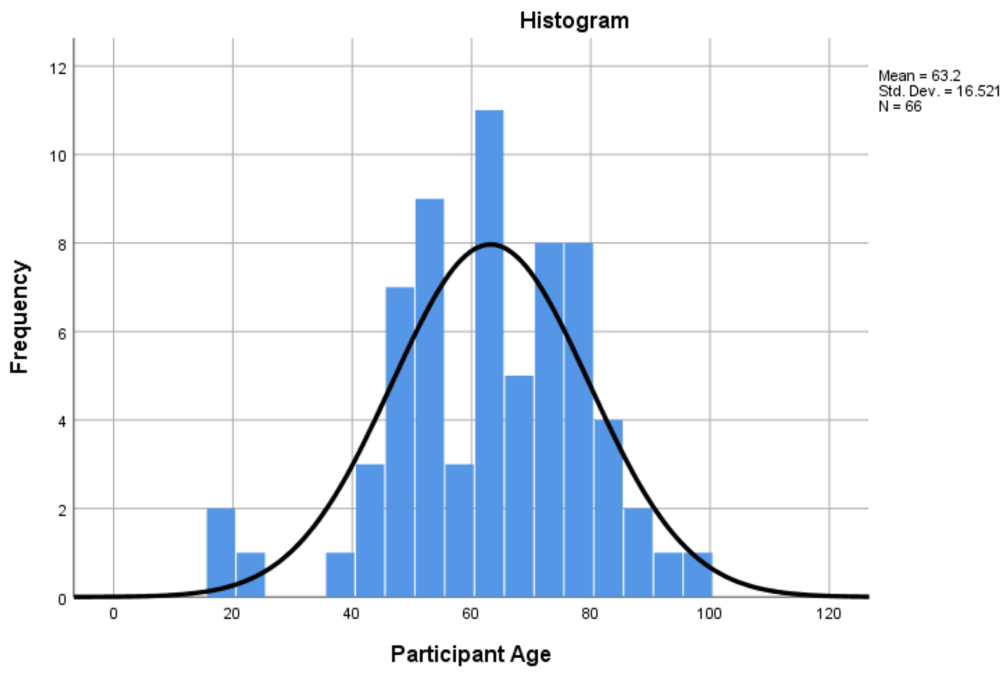


**Figure 4. 1: Mean participants Age**

This study reports that about two thirds (62.1%) of this study's participants were male. More than three quarters (83.3%; n=55) were married, approximately one-third (31.8 %; n=21) had tertiary education, 30.3% (n=20) had secondary education with approximately half (48.5%; n=32) living in Uasin Gishu county (Table 4.1).

**Table 4. 1: Participant Sociodemographic Characteristics**

| **Sociodemographic Characteristics** | | **N (%)** |
|---|---|---|
| Gender | Male | 41 (62.1) |
| | Female | 25 (37.9) |
| Married | Yes | 55 (83.3) |
| | No | 11 (16.7) |
| Level of Education | None | 7 (10.6) |
| | Primary | 18 (27.3) |
| | Secondary | 20 (30.3) |
| | Tertiary | 21 (31.8) |
| County of Residence | Uasin Gishu | 32 (48.5) |
| | Elgeyo Marakwet | 4 (6.1) |
| | Trans Nzoia | 15 (22.7) |
| | West Pokot | 5 (7.6) |
| | Kakamega | 10 (15.2) |

**4.1 Clinical diagnosis of the patients with peripheral arterial disease of the lower limb at MTRH.**

More than two-thirds (68.2%) of the participants had claudication when walking less than 200 meters, with slightly more than half (56.1%) presenting with chronic symptoms while 51.5% had rest pain. Half of the participants reported to have wounds.

**Table 4. 2: Clinical diagnosis of the patients with peripheral arterial disease of the lower limb at MTRH.**

| Clinical Diagnosis | n (%) |
|---|---|
| **Claudication - Walking more than 200m** | 21 (31.8) |
| **Claudication - Walking less than 200m** | **45 (68.2)** |
| **Rest Pain** | **34 (51.5)** |
| **Gangrene** | 16 (24.2) |
| **Diabetic Foot** | 17 (25.8) |
| **Peripheral Pulses** | 28 (42.4) |
| **Wounds on the lower limbs** | **33 (50.0)** |
| **Acute** | 29 (43.9) |
| **Chronic** | **37 (56.1)** |

More than half of this study's participants presented with chronic onset of symptoms (> 2 weeks) compared with the rest who had acute symptoms (at most 2 weeks) as presented on Table 4.3.

**Table 4. 3: Duration of Acute and Chronic onset of symptoms**

| Condition | Duration | n (%) |
|---|---|---|
| **Acute onset of symptoms** | ≤2 weeks | 29 (43.94) |
| **Chronic onset of symptoms** | > 2weeks | 37 (56.06) |

The most common risk factor was cardiovascular disease seen in 47 (71.2%) participants, with hypertension accounting for 34 (72.3%) of these participants.

Diabetes and smoking were seen in 31 and 22 participants respectively with the least common risk factor was trauma among 6 participants.

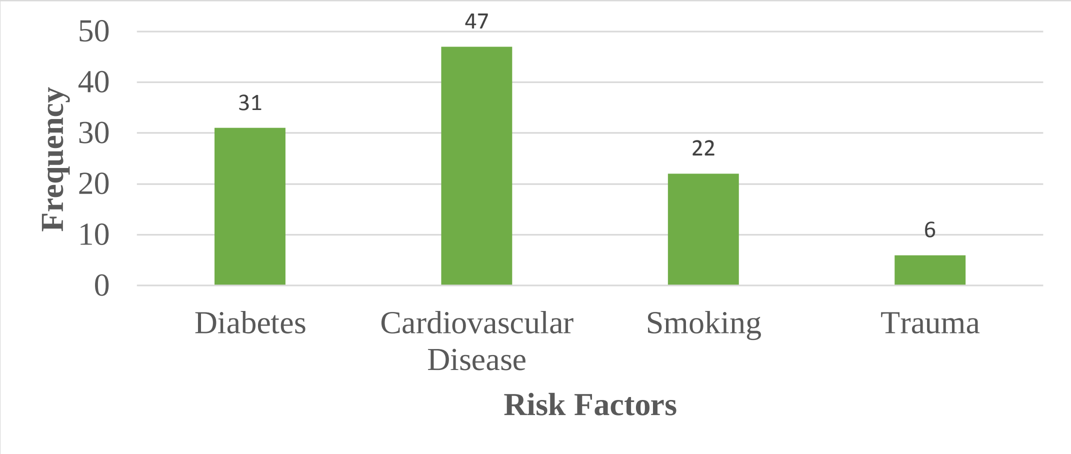


**Figure 4.2: Distribution of Risk Factors**

**4.2 CTA findings of the lower limbs in patients with PVD at MTRH.**

The most occluded arterial segments were posterior tibial at 39.4%, followed by tibioperoneal trunk and anterior tibial artery at 36.4% each. The other CTA findings reported were dorsalis pedis (33.3%; n=22), plantar arches (31.8%; n=21), femoropopliteal (28.8%; n=19), iliofemoral (12.1%; n=8) and aorto-iliac (3.0%; n=2) as shown on Table 4.4.

**Table 4.4: CTA findings of the lower limbs in patients with PAD at MTRH.**

| CTA finding | Occlusion (Complete / Partial) |
|---|---|
| **Aorto-iliac** | 2 (3.0) |
| **Iliofemoral** | 8 (12.1) |
| **Femoropopliteal** | 19(28.8) |
| **Anterior Tibial** | **24(36.4)** |
| **Tibioperoneal Trunk** | **24 (36.4)** |
| **Posterior Tibial** | **26 (39.4)** |
| **Dorsalis pedis** | **22 (33.3)** |
| **Plantar Arches** | 21 (31.8) |

When the severity of ischemia was assessed, 56% of the study participants had limb threatening while the rest (44%) had non-limb threatening ischemia (Figure 4.3).

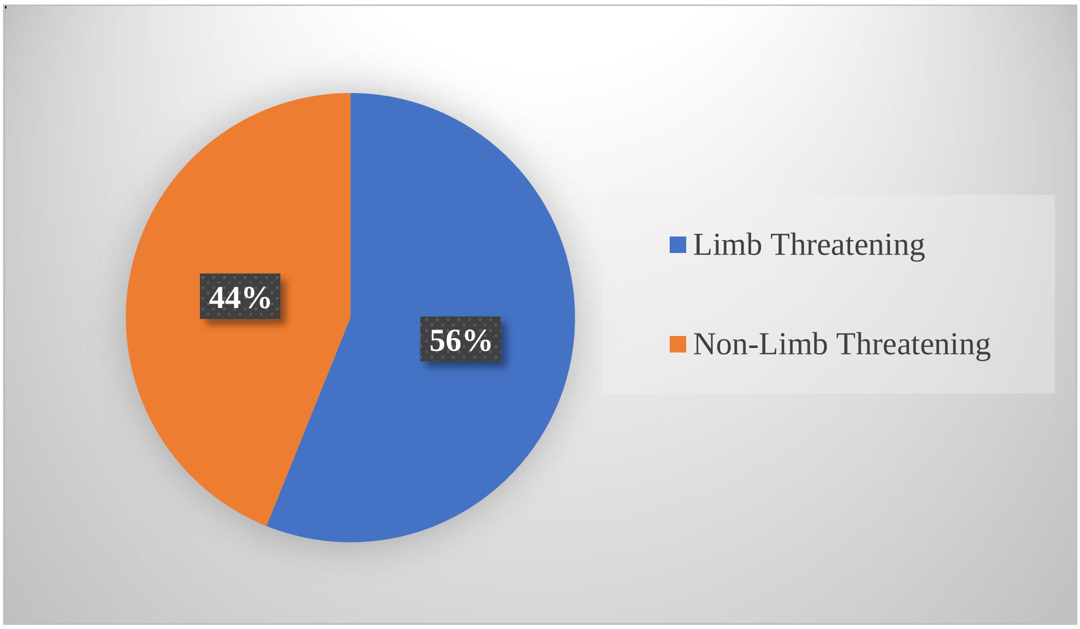


**Figure 4. 3: Severity of Ischemia**

**SAMPLE IMAGES**

The right lower limb arteries of a single participant were found to be patent and had distal run-off from the abdominal aorta; and distally to the dorsalis pedis also seen on the sagittal reconstructed images (Figure 4.4).

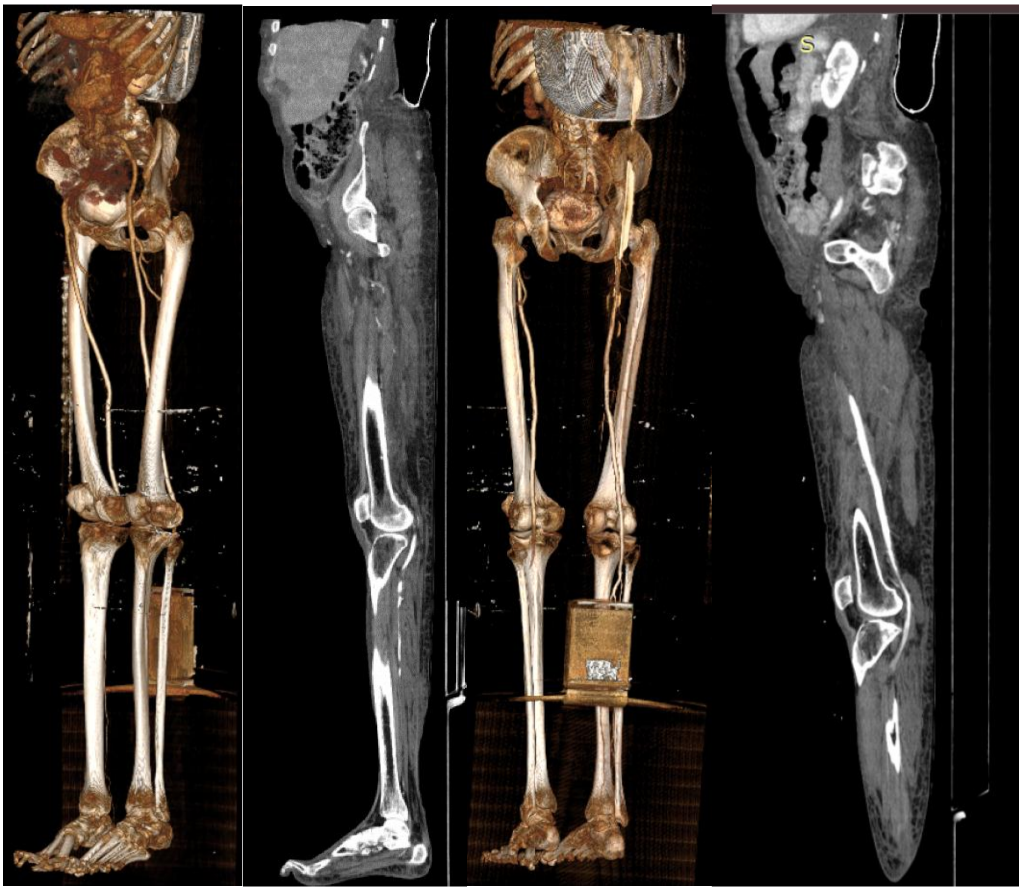


**Figure 4.4:** Selected participants' three-dimensions (3D) images showing the level of occlusion at the right popliteal artery with no distal run-off.

There was an occlusion from the distal popliteal artery with no distal run-off of contrast caudally to the dorsalis pedis artery of the left lower limb (Figure 4.5).

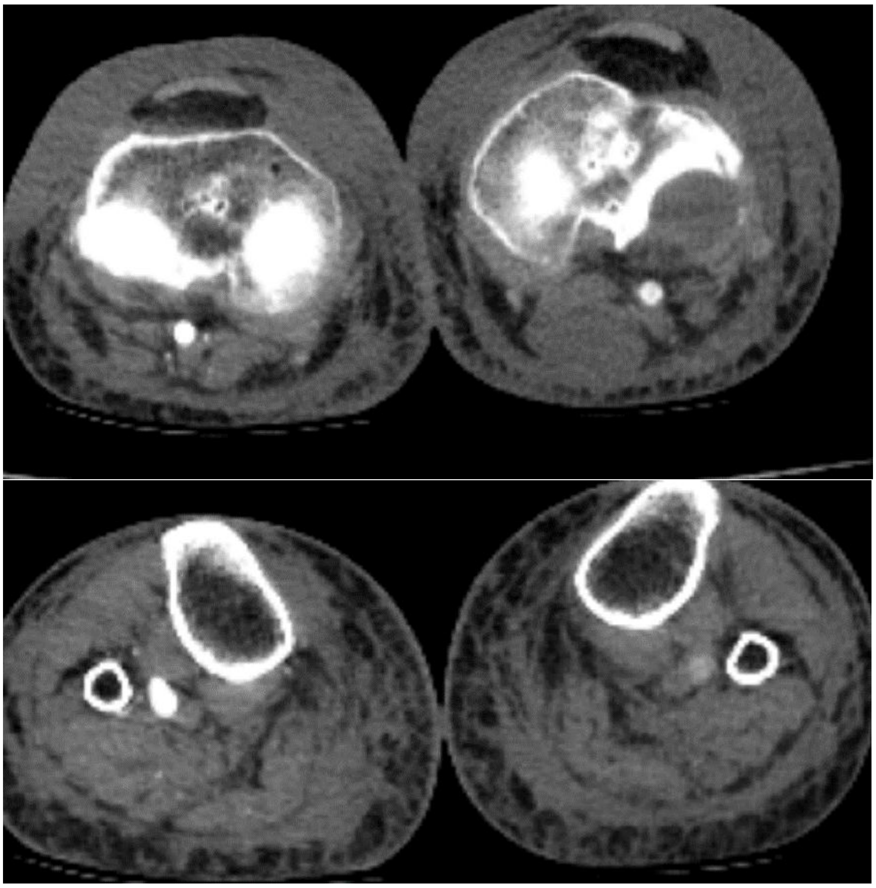

**Figure 4. 5:** Selected participant's CTA images showing features of left lower limb PAD in a 79-year-old female patient with Diabetes Mellitus and hypertension.

### 4.3 Association between CTA findings and treatment plans for patients with peripheral vascular disease of the lower limbs seen at MTRH.

This study assessed if there is a statistically significant relationship between CTA findings and claudication as a symptom of PAD. The study noted that participants diagnosed with iliofemoral (OR= 1.568, 95% CI:1.291, 1.903; p=0.048), anterior tibial (OR= 1.531, 95% CI: 1.132, 2.072; p=0.014), tibioperoneal trunk (OR= 1.531, 95% CI: 1.132, 2.072; p=0.014) and posterior tibial (OR= 1.472, 95% CI: 1.076, 2.012; p=0.030) were significantly more likely to have claudication of < 200 meters (Table 4.5).

**Table 4.5: Association between CTA Finding and Claudication**

| CTA Finding | CLAUDICATION | | p-value | OR (CI: 95%) |
|---|---|---|---|---|
| | < 200 meters (n=45) | >200 meters (n=21) | | |
| **Aorto-iliac** | 2 (4.4) | 0 | 0.327 | 1.488 (1.254, 1.766) |
| **Iliofemoral** | 8 (17.8) | 0 | **0.048** | **1.568 (1.291, 1.903)** |
| **Femoropopliteal** | 16 (35.6) | 3 (14.3) | 0.089 | 1.365 (1.013, 1.838) |
| **Anterior tibial** | 21 (46.7) | 3 (14.3) | **0.014** | **1.531 (1.132, 2.072**) |
| **Tibioperoneal trunk** | 21 (46.7) | 3 (14.3) | **0.014** | **1.531 (1.132, 2.072)** |
| **Posterior tibial** | 22 (48.9) | 4 (19.0) | **0.030** | **1.472 (1.076, 2.012)** |
| **Dorsalis pedis** | 18 (40.0) | 4 (19.0) | 0.160 | 1.333 (0.982, 1.811) |
| **Plantar arches** | 17 (37.8) | 4 (19.0) | 0.163 | 1.301 (0.956, 1.770) |

Additionally, most patients diagnosed with Femoropopliteal (OR=1.436, 95% CI:1.140, 1.810; p=0.015), Anterior tibial (OR=1.680, 95% CI:1.309, 2.156; p<0.001), Tibioperoneal trunk (OR=1.680, 95% CI:1.309, 2.156; p<0.001), Posterior tibial (OR= 1.739, 95% CI: 1.332, 2.270; p<0.001), Dorsalis pedis (OR= 1.630, 95% CI: 1.289, 2.060, p<0.001) and Plantar arches (OR= 1.607, 95% CI:

1.280, 2.018; p=0.001) were significantly more likely to undergo surgical management (Table 4.6).

**Table 4.*6*: Association between CTA Findings and Treatment Plans**

Patients with limb threatening ischemia were significantly more likely (OR=2.417,

| CTA Finding (Occlusions; N=38) | TREATMENT PLAN | | p-value | OR (CI: 95%) |
|---|---|---|---|---|
| | Surgical (n=37) | Conservative (n=1) | | |
| **Aorto-iliac** | 2 (4.1) | 0 | 0.398 | 1.362 (1.175, 1.578) |
| **Iliofemoral** | 8 (16.3) | 0 | 0.101 | 1.415 (1.199, 1.670) |
| **Femoropopliteal** | 18 (36.7) | 1 (5.9) | **0.015** | **1.436 (1.140, 1.810)** |
| **Anterior tibial** | 24 (49.0) | 0 | **<0.001** | **1.680 (1.309, 2.156)** |
| **Tibioperoneal trunk** | 24 (49.0) | 0 | **<0.001** | **1.680 (1.309, 2.156)** |
| **Posterior tibial** | 26 (53.1) | 0 | **<0.001** | **1.739 (1.332, 2.270)** |
| **Dorsalis pedis** | 22 (44.9) | 0 | **<0.001** | **1.630 (1.289, 2.060)** |
| **Plantar arches** | 21 (42.9) | 0 | **0.001** | **1.607 (1.280, 2.018)** |

95% CI: 1.567, 3.727; p<0.001) to undergo surgical management compared to those with non-limb threatening ischemia who received conservative management (Table 4.7).

**Table 4.7: Association between CTA findings (Severity of Ischemia) and treatment plans**

| Severity of Ischemia | Management | | p-value | OR (95% CI:) |
|---|---|---|---|---|
| | Surgical | Conservative | | |
| **Limb Threatening** | 37 (75.5) | 0 | **<0.001** | **2.417 (1.567, 3.727)** |
| **Non-Limb Threatening** | 12 (24.5) | 17 (100.0) | | |
| **Total** | 49 (74.2) | 17 (25.8) | | |

The most common surgical management offered was amputation. This was significantly associated with all occluded segments except aorto-iliac and iliofemoral. Specifically, patients with occluded femoropopliteal (OR=1.632, 95% CI: 1.233, 2.158; p=0.002), Anterior tibial (OR=1.923, 95% CI: 1.320, 2.803;

p<0.001), Tibioperoneal trunk (OR=1.923, 95% CI: 1.320, 2.803; p<0.001), Posterior tibial (OR=2.091, 95% CI: 1.364, 3.204; p<0.001), Dorsalis pedis (OR= 1.800, 95% CI: 1.285, 2.522; p<0.001) and Plantar arches (OR= 1.750, 95% CI: 1.270, 2.412; p<0.001) occluded segments were significantly more likely to be amputated (Table 4.8).

**Table 4.8: Association Between CTA Findings and Surgical Management**

| CTA Finding (Occlusion) | SURGICAL MANAGEMENT | p-value | OR (CI: 95%) |
|---|---|---|---|
| | **Amputation (n=37)** | | |
| **Aorto-iliac** | 2 (5.4) | 0.411 | 1.343 (1.136, 1.588) |
| **Iliofemoral** | 8 (21.6) | 0.173 | 1.414 (1.161, 1.721) |
| **Femoropopliteal** | 18 (48.6) | **0.002** | **1.632 (1.233, 2.158)** |
| **Anterior tibial** | 24 (64.9) | **<0.001** | **1.923 (1.320, 2.803)** |
| **Tibioperoneal trunk** | 24 (64.9) | **<0.001** | **1.923 (1.320, 2.803)** |
| **Posterior tibial** | 26 (70.3) | **<0.001** | **2.091 (1.364, 3.204)** |
| **Dorsalis pedis** | 22 (59.5) | **<0.001** | **1.800 (1.285, 2.522)** |
| **Plantar arches** | 21 (56.8) | **<0.001** | **1.750 (1.270, 2.412)** |

# CHAPTER FIVE

## DISCUSSION

### 5.0 Overview

This study enrolled 66 patients with peripheral arterial disease with a mean age of 63.2 (±16.5) years with the age ranging between 18 to 97 years. This finding is close to that reported in Bosnia (Đurović Sarajlić et al., 2019) at 65.9 (±11.1) years, United Kingdom (Fotiadis et al., 2011) at 66.1 (±11.7) years and Egypt (Assaad-Khalil et al., 2015) at 57.3 (±10.5) years. This finding implies that majority of patients with PAD are elderly. However, lower mean age with a wider standard deviation was reported in a study conducted in Nigeria (Joseph & Ebenezer, 2020) where the mean age for patients presenting with vascular pathology at a Nigerian Tertiary Hospital was 46.0 (±20.3) years. This proportionate difference could be attributed to a larger sample size (n=305) adopted in Nigeria (Joseph & Ebenezer, 2020). The larger the sample size the greater the likelihood of a more diverse and heterogenous population compared to smaller sample sizes.

Additionally, this study enrolled more male (62.1%) participants compared to their female counterparts (37.9%). This finding on a higher proportionate enrolment of male participants is comparable to that reported in Nigeria (Joseph & Ebenezer, 2020) at 55.7%, United Kingdom (Fotiadis et al., 2011) at 56% but lower than Bosnia (Đurović Sarajlić et al., 2019) where a much higher proportion (75%) of male participants were enrolled. Male participants could present more with peripheral arterial disease compared to females due to a discordance in health seeking behaviour among male compared to females, as well as previous epidemiological trends that have shown males to be disproportionately affected by

PAD compared to females (Natha et al., 2014; Shu & Santulli, 2018; Shwaiki et al., 2021).

### 5.1 Clinical diagnosis of the patients with peripheral vascular disease of the lower limb at MTRH.

More than two thirds (68.2%) of this study's participants had a severe claudication (walking less than 200 meters) compared to those with moderate claudication (Walking more than 200m) at 31.8%. This finding is in tandem to that reported in Germany (Preuß et al., 2016b) and Egypt (Gamal El Dein et al., 2019) where less than half of those enrolled reported moderate claudication at 49.9% and 48.1% respectively. Although, there was a nearly equal proportions of moderate and severe claudication in the study conducted in Germany, the authors (Preuß et al., 2015) enrolled a higher number of participants (n=429) and was conducted in a country with a better socioeconomic status and health seeking behaviour. This increases the likelihood of screening and diagnosing patients suspected to have PAD much earlier than was the case in the current study conducted in Kenya. A similar trend was also noted in the study conducted in Egypt (Gamal El Dein et al., 2019).

The proportion of rest pain was higher in the current study at 51.5% compared to that reported in Egypt at 18.5% (Gamal El Dein et al., 2019). Pain is a hallmark for many pathological conditions and is a major motivator for patients to visit healthcare facilities. Most of these patients often present with a severe or advanced state of the disease.

More than half of this study's participants had chronic symptoms compared to those with acute onset of symptoms. This finding compares to that in Germany

(Werncke, 2015) where more than half (70.4%) had chronic symptoms. This implies delayed health seeking behaviour among patients with peripheral arterial disease. Patients with cardiovascular disease formed the greatest proportion (71.2%), of those with risk factors for peripheral arterial disease, followed by Diabetes (47.0%). This proportion of cardiovascular disease was higher than that reported in Bosnia (Vesna, 2019) at 7.4%. The proportion of hypertension reported in this study is close to that reported in Egypt (Gamal, 2019) at 48.1% and South Korea (Park, 2021) at 46.6%. Higher proportions of hypertension were reported in Italy (Napoli, 2011) at 70% while lower proportions were noted in Bosnia (Vesna, 2019) at 16.7%.

The proportion of diabetes in this study matches that reported in Bosnia (Park, 2021) at 41.7% and South Korea (Park, 2021) 43.5%. This finding corroborates previously published studies that have noted diabetes to be a major risk factor for peripheral arterial disease.

**5.2 CTA findings of the lower limbs in patients with PAD at MTRH.**

Thid study noted that posterior tibial occlusion (39.4%) was the most common CTA findings among the patients with peripheral arterial disease who enrolled in this study. This finding is close to that reported in Egypt at (Gamal, 2019) but way higher that that reported in China at 2.5% (Zhang, 2022). This difference in proportion with the study conducted in China (Zhang, 2022) where the most common CTA finding was femoropopliteal occlusion at 36.4%. The femoropopliteal finding reported in China is marginally higher than the current study which reported a proportion of 28.8%. Higher femoropopliteal occlusion findings were reported in Italy (Martinelli, 2020) at 81.9% while a lower proportion was noted in Egypt (Gamal, 2019) at 14.8%.

There were nearly equal proportions anterior tibial (36.6%), tibioperoneal trunk (36.4%), dorsalis pedis (33.3%) and plantar arches (31.8%) among the participants enrolled in this study. The proportions of anterior tibial occlusion were higher than that reported in both Egypt and China at 26% and 18.2% respectively. Although this study noted equal proportions of tibioperoneal trunk and anterior tibial findings, the proportions of tibioperoneal trunk in this study are much lower than that reported in Egypt (Gamal, 2019) at 88.9% while in China, only 1.5% (Zhang, 2022) of the participants were noted to have an occlusion on their tibioperoneal trunk. One third (33.3%) of this study's respondents had an occlusion on the dorsalis pedis segment a finding that was way higher than the one reported in China at 1.5% (Zhang, 2022).

This study found a statistically significant association between iliofemoral, anterior tibial, tibioperoneal trunk and posterior tibial and claudication. The findings matched those reported in The Netherlands (Jens, 2013) where a statistically significant association was noted. In Germany (Preuß, 2016), there was a statistically significant association between Dorsalis-pedis, Plantar arches and Claudication. This is because CTA of lower extremities allows for differentiation of vascular and musculoskeletal causes of intermittent claudication in a single examination (Preuß, 2016).

**5.3 To analyse the association between CTA findings and treatment plans for patients with peripheral vascular disease of the lower limbs seen at MTRH.**

This study notes a statistically significant association between CTA finding and surgical management plan. The finding matches the Society for Vascular Surgery practice guidelines (Conte, 2015) that recommend Surgical reconstruction or endovascular approaches for Aorto-iliac CTA finding and angioplasty for Iliofemoral finding. Similarly in Vienna – Austria (Schernthaner, 2008), endovascular and surgical approaches were informed by CTA finding. Preuß, 2016 revealed that more than half of the patients had vascular therapy based on their imaging findings.

Participants with limb threatening ischemia had a two-fold significant likelihood of surgical management compared to those with non-limb threatening ischemia. This finding is comparable to that reported in San Francisco (USA) where patients with limb threatening ischemia were more likely to receive amputation, endovascular or open surgical revascularization. In a case study (Farber, 2018), revascularizing was not recommended for patients with limb threatening ischemia. The author (Farber, 2018) recommended primary major amputation below or above the knee.

This study noted a statistically significant association between femoropopliteal, anterior tibial, tibioperoneal trunk, posterior tibial, dorsalis pedis, plantar arches CTA findings and amputation. The findings are comparable to that reported in Germany (Preuß, 2016) where patients with adverse CTA findings were significantly more likely to be amputated.

# CHAPTER SIX

## 6.0 CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

### 6.1 Conclusions

1. Majority of patients diagnosed with PAD of the lower limbs at MTRH were elderly males, with a claudication of walking less than 200-meter, rest pain and chronic symptoms.
2. The most common CTA finding was occlusion of posterior tibial artery, followed by equal proportions of tibioperoneal trunk and anterior tibial, with the least frequent being aortoiliac.
3. All CTA findings except aorto-iliac were significantly associated with surgical management with amputation being the predominant surgical management.

### 6.2 Recommendations

1. There is need to screen for PAD of the lower limbs at MTRH among elderly males, with a claudication of walking less than 200-meter walk, rest pain, chronic onset of symptoms and pre-existing conditions such as cardiovascular disease and diabetes.
2. CTA clearly depicts the courses of vessels not only in patent but also in completely occluded segments. Such depictions provide useful information for planning endovascular revascularization procedures.
3. This study stimulates further inquiry and scholarship, creating the need for a larger study to elucidate additional risk factors.

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# APPENDICES

## APPENDIX I: CONSENT FORM

My name is Brenda Muthoni Kang'ethe a postgraduate student in Diagnostic Radiology and Imaging from Moi University, Eldoret. I am conducting a study on clinical utilization of multi-slice computed tomography angiography and resultant interventions on peripheral vascular disease of the lower limbs among patientsat Moi Teaching and Referral Hospital (MTRH) in Eldoret.

Multislice computed tomography angiography involves taking images of your blood vessels to determine whether there is a blockage (clot) or not. You have been selected to participate in this study because your doctor suspects that you might have a clot on the blood vessels of your lower-limbs hence a for a computed tomography angiography of the lower limbs.

Your participation in this study is entirely voluntary and you may withdraw at any time of the study if you so wish. This study has been approved by the Moi University-MTRH Ethics committees and will ensure that all your rights as a study participant are protected

Your participation in this study will not in any way interfere with the current clinical care you are receiving in this facility and all the information obtained from you will be treated with atmost confidentiality. This is a minimal risk study as the only discomfort you will experience will be during contrast injection which will be conducted by a trained professional as part of clinical care.

This study is important to both you and the community in understanding the computed tomography angiography findings and resultant interventions and will generate new knowledge in the diagnosis and management of blockages in the blood vessels of the lower limbs..The findings from this study will be conveyed to you and other stakeholders and published in scientific journals and also presented in scientific seminars and conferences.

In case of any questions or concerns, feel free to contact me through my telephone number 0712294426 or the Chairman of Moi University-MTRH Ethics committee at the MTRH Building 2nd Floor.

**Declaration**

I have read (been read to) this consent and all my concerns have been addressed. I therefore agree to participate in this study.

Participant Signature and Initials__________________Date__________________

Consenter's signature: _________________________ Date __________________

**FOMU YA RIDHARA**

Jina langu ni Brenda Muthoni Kang'ethe mwanafunzi wa uzamili katika Utambuzi wa Radiolojia na Upigaji picha kutoka Chuo Kikuu cha Moi, Eldoret. Ninafanya utafiti juu ya utumiaji wa kliniki wa angografia ya hesabu ya hesabu nyingi na hatua zinazosababishwa na ugonjwa wa mishipa ya pembeni ya miguu ya chini kati ya wagonjwa katika Hospitali ya Kufundisha na Rufaa ya Moi (MTRH) huko Eldoret.

Angiografia ya hesabu ya kompyuta nyingi inajumuisha kuchukua picha za mishipa yako ya damu kuamua ikiwa kuna uzuiaji (kuganda) au la. Umechaguliwa kushiriki katika utafiti huu kwa sababu daktari wako anashuku kuwa unaweza kuwa na kitambaa kwenye mishipa ya damu ya miguu na mikono yako ya chini kwa hivyo angiografia ya hesabu ya miguu ya chini.

Kushiriki kwako katika utafiti huu ni kwa hiari kabisa na unaweza kujiondoa wakati wowote wa utafiti ikiwa unataka. Utafiti huu umeidhinishwa na kamati za Maadili za Chuo Kikuu cha Moi-MTRH na itahakikisha kuwa haki zako zote kama mshiriki wa utafiti zinalindwa.

Ushiriki wako katika utafiti huu hautaingiliana kwa vyovyote na huduma ya kliniki unayoipata katika kituo hiki na habari zote zilizopatikana kutoka kwako zitashughulikiwa kwa usiri kabisa. Huu ni utafiti mdogo wa hatari kwani usumbufu tu utakaopata utakuwa wakati wa sindano ya kulinganisha ambayo itafanywa na mtaalamu aliyefundishwa kama sehemu ya utunzaji wa kliniki.

Utafiti huu ni muhimu kwako wewe na jamii katika kufahamu matokeo ya hesabu ya hesabu ya hesabu na uingiliaji unaotokana na hiyo na itatoa maarifa mapya katika utambuzi na usimamizi wa vizuizi kwenye mishipa ya damu ya viungo vya chini .. Matokeo ya utafiti huu yatasambazwa kwako na wadau wengine na kuchapishwa katika majarida ya kisayansi na pia kuwasilishwa katika semina na mikutano ya kisayansi.

Ikiwa kuna maswali yoyote au wasiwasi, jisikie huru kuwasiliana nami kupitia nambari yangu ya simu 0712294426 au Mwenyekiti wa kamati ya Maadili ya Chuo Kikuu cha Moi-MTRH katika Jengo la MTRH Sakafu ya 2.

Azimio

Nimesoma (nimesomewa) idhini hii na wasiwasi wangu wote umeshughulikiwa. Kwa hivyo ninakubali kushiriki katika utafiti huu.

Saini ya Washiriki na Hati za Kwanza ________________________

Saini ya Mtumiaji: ________________________ Tarehe _________________

**APPENDIX II: QUESTIONNAIRE**

**STUDY NUMBER………………………**

**SECTION A: DEMOGRAPHIC DATA**

AGE……………………………….

GENDER: MALE ☐ FEMALE ☐

MARRIED: YES ☐ NO ☐

EDUCATION……………………………………….

COUNTY OF RESIDENCE……………………………………….

**SECTION B: what was the clinical presentation of the patient referred for CTA lower limb?**

| Claudication<br><br>Walking more than 200m<br>Walking less than 200m | Present | Absent |
|---|---|---|
| Rest pain | | |
| Gangrene | | |
| Diabetic foot | | |
| Presence or absence peripheral pulses | | |
| Ulcer /wounds | | |
| Acute (specify period) | | |
| Chronic (specify period) | | |
| Trauma | | |

**SECTION C: what are the risk factors**

| DM | HTN | Cardiovascular disease | HIV | Smoking |
|---|---|---|---|---|
| | | | | |
| | | | | |

**SECTION D: previous imaging modality and findings**

| | |
|---|---|
| Yes (specify) | |
| No | |

**SECTION E: CTA Findings (sites of vessel occlusion, length, presence of calcification)**

| | |
|---|---|
| Aorto-iliac | |
| Iliofemoral | |
| Femoropopliteal | |
| Tibioperoneal | |

**SECTION F: CTA Finding (severity of ischemia)**

Limb threatening

Non-limb threatening

**SECTION G: Clinical management**

Surgical:

- Amputation – major
  Minor
- Debridement

Conservative management

# APPENDIX III: IREC APPROVAL

**INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)**

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/030/2021
***Approval Number: 0003975***
Dr. Brenda Kang'ethe Muthoni,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
**ELDORET-KENYA.**

9th September, 2021

Dear Dr. Kang'ethe,

**COMPUTED TOMOGRAPHY ANGIOGRAPHY AS A DIAGNOSTIC TOOL FOR MANAGEMENT IN PATIENTS WITH LOWER LIMB PERIPHERAL VASCULAR DISEASE AT MOI TEACHING AND REFERRAL HOSPITAL**

This is to inform you that ***MTRH/MU-IREC*** has reviewed and approved your above research proposal. Your application approval number is ***FAN: 0003975.*** The approval period is **9th September, 2021- 8th September, 2022.** This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, Material Transfer Agreements (MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MTRH/MU-IREC.***
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MTRH/MU-IREC*** within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MTRH/MU-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from ***MOH at the recommendation of NACOSTI*** for each batch of shipment.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MTRH/ MU-IREC.***

Prior to commencing your study; you will be required to obtain a research license from the National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and other relevant clearances from study sites including a written approval from the CEO-MTRH which is mandatory for studies to be undertaken within the jurisdiction of Moi Teaching & Referral Hospital (MTRH) and its satellites sites.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
09 SEP 2021
APPROVED
P. O. Box 4606-30100 ELDORET

Sincerely,

**PROF. E. WERE**
**CHAIRMAN**
**INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cc | CEO | - | MTRH | Dean | - | SOP | Dean | - | SOM |
| | Principal | - | CHS | Dean | - | SON | Dean | - | SOD |

# APPENDIX IV: MTRH APPROVAL

An ISO 9001:2015 Certified Hospital

**MOI TEACHING AND REFERRAL HOSPITAL**

Telephone :( +254)053-2033471/2/3/4
Mobile: 722-201277/0722-209795/0734-600461/0734-683361
Fax: 053-2061749
Email: ceo@mtrh.go.ke/directorsofficemtrh@gmail.com

Nandi Road
P.O. Box 3 – 30100
ELDORET, KENYA

**Ref:** ELD/MTRH/R&P/10/2/V.2/2010

10th September, 2021

Dr. Kang'ethe Brenda Muthoni
Moi University
School of Medicine
P.O. Box 4606-30100
**ELDORET-KENYA**

**COMPUTED TOMOGRAPHY ANGIOGRAPHY AS A DIAGNOSTIC TOOL FOR MANAGEMENT IN PATIENTS WITH LOWER LIMB PERIPHERAL VASCULAR DISEASE AT MOI TEACHING AND REFERRAL HOSPITAL**

You have been authorised to conduct research within the jurisdiction of Moi Teaching and Referral Hospital (MTRH) and its satellites sites. You are required to strictly adhere to the regulations stated below in order to safeguard the safety and well-being of staff, patients and study participants seen at MTRH.

1 The study shall be under Moi Teaching and Referral Hospital regulation.
2 A copy of MTRH/MU-IREC approval shall be a prerequisite to conducting the study.
3 Studies intending to export human bio-specimens must provide a permit from MOH at the recommendation of NACOSTI for each shipment.
4 No data collection will be allowed without an approved consent form(s) to participants unless waiver of written consent has been granted by MTRH/MU-IREC.
5 Take note that **data** collected must be treated with due confidentiality and anonymity.

The continued permission to conduct research shall only be sustained subject to fulfilling all the requirements stated above.

10/09/2021

10 SEP 2021

**DR. WILSON K. ARUASA, *EBS***
**CHIEF EXECUTIVE OFFICER**
**MOI TEACHING AND REFERRAL HOSPITAL**

cc - Senior Director, Clinical Services
- Director of Nursing Services
- HOD, HRISM

*All correspondence should be addressed to the Chief Executive Officer*
*Visit our Website:* ***www.mtrh.go.ke***
TO BE THE LEADING MULTI-SPECIALTY HOSPITAL FOR HEALTHCARE, TRAINING AND RESEARCH IN AFRICA

# APPENDIX V: NACOSTI APPROVAL

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **270825**

Date of Issue: **02/April/2022**

## RESEARCH LICENSE

**This is to Certify that Dr.. Brenda Muthoni of Moi University, has been licensed to conduct research in Uasin-Gishu on the topic: COMPUTED TOMOGRAPHY ANGIOGRAPHY AS A DIAGNOSTIC TOOL FOR MANAGEMENT IN PATIENTS WITH LOWER LIMB PERIPHERAL VASCULAR DISEASE AT MOI TEACHING AND REFERRAL HOSPITAL for the period ending : 02/April/2023.**

License No: **NACOSTI/P/22/16683**

**270825**

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

**Appendix 1V:Time Plan**

| ACTIVITY | START | END |
|---|---|---|
| PROPOSAL CONCEPT DEVELOPMENT | March 2020 | April2020 |
| PROPOSAL WRITING | May 2020 | December 2020 |
| IREC APPROVAL | May 2021 | July 2021 |
| DATA COLLECTION | September 2021 | August 2022 |
| DATA ANALYSIS | September 2022 | October 2022 |
| THESIS WRITING | November 2022 | December 2022 |

**Appendix V: Budget**

| ITEM | QUANTITY | UNIT PRICE(KSHS) | TOTAL(KSHS) |
|---|---|---|---|
| Laptop Computer | 1 | 50,000 | 50,000 |
| Printing and photocopying | - | 13,000 | 13,000 |
| Stationery | - | 5,000 | 5,000 |
| Storage Devices | 50 | 20 | 1,000 |
| Statistical Consultation | - | 15,000 | 15,000 |
| Internet services and communication | - | 10,000 | 10,000 |
| Publication | - | 50,000 | 50,000 |
| Follow-up expenses | 70 | 300 | 2500 |
| GRAND TOTAL | - | - | 150,500 |