

Target vessel revascularization of diabetic foot according to angiosomes

*Thesis Submitted for Partial Fulfillment of
Master Degree
in general Surgery*

By

**Sherif Mohammed Abdel Aziz
M.B., B.Ch. Mansoura University**

Under Supervision of

**Prof. Dr. Adel Abdel Aziz Sied
Professor of general Surgery
*Faculty of Medicine, Ain Shams University***

**Prof. Dr. Mohammed Abdel Monaem Rizk
Assistant professor of general and vascular surgery
*Faculty of Medicine, Ain Shams University***

**Faculty of Medicine
Ain Shams University**

2019



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

وقل رب زدني علماً

صدق الله العظيم

سورة طه آية (١١٤)





ACKNOWLEDGEMENTS

*All Praise is due to **ALLAH***

I wish to express my deepest gratitude to all those who assisted me to complete this work,

*First and foremost, my thanks are directed to **Prof. Dr. Adel Abdel Aziz Sied**, Professor of General Surgery, Faculty of Medicine, Ain Shams University, for his unlimited help and continuous insistence on perfection, without his constant supervision, this thesis could not have achieved its present form.*

*Great thanks and appreciation to **Prof. Dr. Mohammed Abdel Monaem Rizk**, assistant professor of General & Vascular Surgery, Faculty of Medicine, Ain Shams University, for his supervision and encouragement and for his kindness throughout the work, and for his effective participation and meticulous revision of every step during this work.*

I wish to thank all patients who participated in the present study, and every person who has contributed assistance during preparation of this work,

Finally, I appreciate the most help of my family. They always supply me with the feeling of hope, love and encouragement.



CONTENTS

	<i>Page</i>
❖ <i>List of Abbreviations</i>	i
❖ <i>List of figures</i>	iii
❖ <i>List of tables</i>	v
❖ <i>Introduction</i>	1
❖ <i>Aim of the work</i>	4
❖ <i>Review of literature</i>	
• Surgical anatomy of arteries of the lower limb	5
• Pathology of PAD	11
• Chronic limb threatening ischemia	17
• Modalities of treatment of CLTI	27
• Angiosome based angioplasty	34
❖ <i>Patients and methods</i>	41
❖ <i>Results</i>	51
❖ <i>Discussion</i>	67
❖ <i>Summery and conclusion</i>	74
❖ <i>References</i>	77
❖ <i>Arabic summary</i>	1-3

LIST OF ABBREVIATIONS

PAD	: Peripheral arterial disease
CLTI	: Chronic limb threatening ischemia
PAOD	: Peripheral arterial occlusive disease
BMT	: Best medical treatment
ABI	: Ankle brachial index
CFA	: Common femoral artery
SFA	: Superficial femoral artery
PFA	: Profunda femoris artery
ATA	: Anterior tibial Artery
PTA	: Posterior tibial Artery
SMC	: Smooth muscle cell
PTFE	: Polytetrafluoroethylene synthetic graft
HBO	: Hyperbaric oxygen
TCOM	: Transcutaneous oxygen measurements
PSV	: Peak systolic velocity
VR	: Velocity ratio
MRA	: Magnetic resonance angiography
DSA	: Digital subtraction angiography
IVUS	: Intravascular ultrasound
CV	: Cardiovascular
LEAD	: Lower extremity artery disease
PG	: Prostaglandins
CTA	: Computed Tomographic Angiography
IHD	: Ischemic heart disease
Rt	: Right

Lt	: Left
DR	: Direct revascularization
IR	: Indirect revascularization
CR	: Combined revascularization
MAP	: Mitogen-activated Protein
PKC	: Protein Kinase-C
SHP-1	: Src Homology-2 domain-containing Phosphatase-1
BKA	: Below knee amputation
NSAIDs	: Non-steroidal anti-inflammatory drugs

LIST OF FIGURES

Figure No.	Title	Page
1	Major arteries of the lower limb	5
2	Angiosomes of the foot	7
3	Vascular anatomy of the foot and ankle	8
4	Vascular anatomy of the foot	9
5	Vascular anatomy of the foot and ankle	10
6	Steps of of atheromatous plaque formation and maturation	12
7	Consequences of endothelial dysfunction	13
8	Thrombotic complication of fibroatheroma	15
9	Scheme of hyperglycemia's induced pathways to microvascular complications	16
10	Ankle brachial index	18
11	Segmental limb pressures	19
12	CTA showing infra-popliteal disease	21
13	MRA of both lower limbs	22
14	Conventional angiography	23
15	algorithm for treatment of critical limb ischemia	27
16	Subintimal recanalization of PTA, endoluminal recanalization of ATA	38
17	Retrograde puncture of ATA, Safari technique, antegrade angioplasty	39
18	Distal ATA angioplasty via peroneal artery	40
19	Gender distribution among studied patients	51

20	Age distribution among studied patients	52
21	Co-morbid factors in studied patients	52
22	Side of the lesion in studied patients	53
23	Angiosome based lesion	54
24	Technical success among studied patients	55
25	Groups of the study	56
26	A case of direct revascularization	59,60
27	A case of indirect revascularization	61,62
28	A case of combined revascularization	64,65

LIST OF TABLES

Table No.	Title	Page
1	Duplex classification of peripheral arterial occlusive disease	21
2	WIFI classification	25
3	Clinical staged based on WIFI classification	26
4	Interpretation of ankle brachial index	43
5	Demographic data of the patients	51
6	Co-morbid factors in studied patients	52
7	Side of the lesion in studied patients	53
8	Angiosome based lesion	54
9	Technical success among studied patients	55
10	Groups of the study	56
11	Demographic data of the groups	57
12	Follow up of the groups of the patients	66

INTRODUCTION

Peripheral arterial disease (PAD) is a major world-wide health problem that affects 12%–14% of the general population. There are several risk factors that contribute for the development and progress of PAD including diabetes mellitus, hypertension, hyperlipidemia and smoking. **(Misra., 2012).**

Chronic limb threatening ischemia (CLTI) is defined as patients with ischemic rest pain or with ischemic skin lesions, either ulcers or gangrene. The term CTLI should only be used in relation to patients with chronic ischemic disease and symptoms that lasts for more than 2 weeks. **(Dormandy and Rutherford., 2000).**

CLTI due to infra-popliteal arterial disease is associated with a higher rate of limb loss. These patients have a higher mortality rates compared to patients whose limbs can be saved. Therefore, aggressive limb salvage attempts are justified in CLTI patients. **(Faglia et al., 2014).**

The diagnosis of peripheral arterial occlusive disease (PAOD) is usually made clinically depending on medical history and ankle–brachial index (ABI) measurements. According to Fountaine classification, stage I PAOD is asymptomatic. Stage II is characterized by intermittent claudication. Rest pain and ulcerations are the clinical characteristics of stages III and IV PAOD, respectively. **(Scherthaner et al., 2009).**

There are different modalities of management of chronic lower limb ischemia. Firstly, best medical treatment (BMT) that includes regular exercise, smoking cessation, blood pressure control, good control of blood sugar, regulation of lipid level and pharmacologic medications that improve the peripheral blood flow. **(Dormandy and Rutherford., 2000).**

Surgical re-vascularization is another alternative for treating chronic lower limb ischemia patients. Infra-popliteal arterial disease is not usually suitable for surgical bypass. Angioplasty is an expanding era by dilatation of narrowed or occluded arterial segment with minimal invasion. **(Dormandy and Rutherford., 2000).**

Infra-popliteal angioplasty has acceptable rates of limb salvage in patients with CLTI with high risk for surgery. The procedure has low morbidity and mortality with lower costs compared with surgical revascularization. Aggressive angioplasty should be an option when primary amputation would be the other available one. **(Werneck and Lindsay., 2009).**

The main problem is to find a way to provide sufficient blood flow to the ischemic area. This may lead to either direct revascularization of the ischemic area or indirect perfusion depending on collaterals surrounding the diseased zone. The arterial connections between different zones of the foot may not be sufficient to ensure healing and to prevent amputation. **(Kret et al., 2014).**

All this debate arouse the need for an alternative strategy, called the angiosome model, which is target vessel reperfusion, based on the pioneering work of Taylor and coworkers who performed detailed dissections with injection of dye in the vessels. They demonstrated the fact that the body consists of angiosomes. An angiosome is a 3-dimensional blocks of tissue perfused and drained by specific arterial and venous bundles. (**Attinger et al., 2006**).

AIM OF THE WORK

The aim of this work is to discuss the clinical benefit in wound healing and limb preservation after infra-popliteal endovascular revascularization guided by an angiosome model of perfusion in the healing process of ischemic diabetic foot ulcers.

SURGICAL ANATOMY OF THE LOWER LIMB ARTERIAL SYSTEMS

The common femoral artery (CFA) enters the thigh by passing behind the inguinal ligament midway between the anterior superior iliac spine and the symphysis pubis. It divides 2 to 5 cm below the inguinal ligament into profunda femoris artery (PFA) and the superficial femoral artery (SFA) which ends at the opening of the adductor magnus muscle as popliteal artery. **(Richard et al., 2003).**

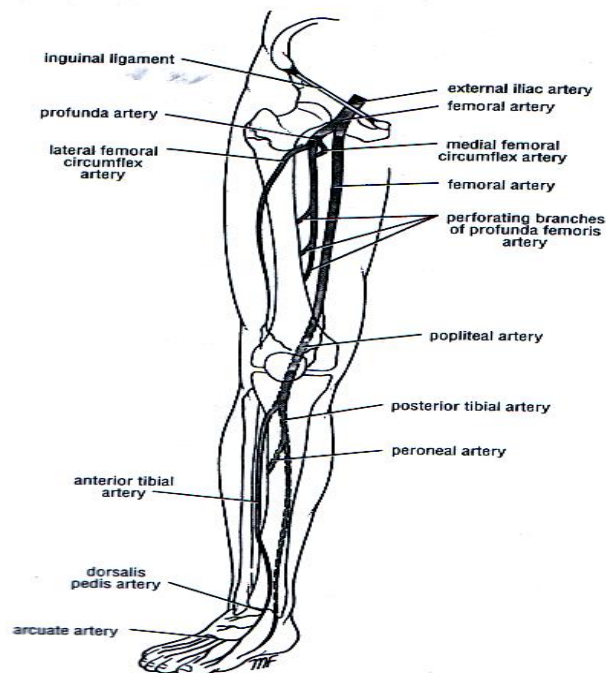


Fig. (1) Major arteries of the lower limb.
(Quoted from **Richard., 2003**).

The popliteal artery traverses the popliteal fossa from the opening in adductor magnus muscle and descends laterally to the distal border of popliteus muscle where it divides into the anterior tibial artery and tibioperoneal trunk. (Gray., 2005).

The anterior tibial artery (ATA) supplies the anterior ankle and continues as the dorsalis pedis artery, which supplies the dorsum of the foot. It gives off the lateral tarsal artery and branches into the first dorsal interosseal artery and the arcuate artery supplying the 2 - 4 interosseal arteries. (Clemens et al., 2010).

The posterior tibial artery (PTA) divides into three branches. The calcaneal branch, which supply the medial and plantar portion of the heel. The medial plantar artery, supplying the medial, plantar part of the foot. The lateral plantar artery which supplies the lateral midfoot as well as the entire plantar forefoot. (Clemens et al., 2010).

The peroneal artery bifurcates into two branches. The anterior perforating branch, supplying the lateral anterior upper ankle. The calcaneal branch, supplying the lateral and plantar aspect of the heel. (Clemens et al., 2010).