Outcome of endovascular intervention in isolated tibial arterial occlusive disease versus combined tibial and superficial femoral artery disease

Thesis

Submitted by

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بسم الله الرحمن الرحيم

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SHERIF HUSSEIN

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DEB	Drug eluting ballon
PAD	Peripheral arterial disease
CLI	Critical limb ischaemia
MI	Myocardial infarction
DM	Diabetes mellitus
SFA	Superficiel femoral artery
ATA	Anterior tibial artery
TPT	Tibio-peroneal trunk
PTA	Posterior tibial artery
PRA	Peroneal artery
DPA	Dorsalis paedis artery
FDMA	First digital metatarsal artery
DMA	Digital metatarsal artery
VSMC	Vascular smooth muscle cells
LDL	Low denisty lipoprotiens
SMC	Smooth muscle cells
ACC	American college of cardiology
AHA	American heart association

CHD	Coronary heart disease
HDL	High denisty lipoprotiens
PVD	Peripheral vascular disease
ABI	Ankle brachial index
IC	Intermittent claudications
ALI	Acute limb ischaemia
CDI	Colour duplex imaging
TASC	Trans-atlantic Inter -Society Consencus
CTA	Computed tomography angiogram
MRA	Magnetic resonace imaging
DSA	Digital subtraction angiography
PG	Prostaglandins
LMWH	Low molecular weight heparin
CFA	Common femoral artery
PTA	Percutanous transluminal angioplasty
CB	Cutting ballons
SE	Self expandable
BE	Ballon expandable
ISR	In-stent stenosis

SES	Sirolimus eluting stent
AMS	Absorbable metal stent
CTO	Chronic total occlusion

INTRODUCTION

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Peripheral arterial disease (PAD), also known as chronic lower extremity ischemia, is the most common cause of loss of normal walking ability seen by the vascular specialist. The presence of PAD is a strong marker for the presence of coronary artery and cerebrovascular disease. **(Hirsch et al., 2001)**

Critical limb ischemia (CLI) is a severe form of PAD and it is defined as persistent, recurring ischemic rest pain requiring analgesia for at least 2 weeks, ulceration or gangrene of the foot or toes with ankle systolic pressure less than 50 mm Hg or toe systolic pressure less than 30 mm Hg.

(Norgren et al., 2007)

The two major classifications based on the clinical presentations of CLI and in general PAD into grades and categories are:

a) The Fontaine classification, in which CLI is classified as Fontaine III and Fontaine IV: in which ischemic rest pain is classified as Fontaine III and patients suffer tissue loss, such as ulceration or gangrene, is classified as Fontaine IV.

b) The Rutherford classification, in which CLI is classified as: patients with rest pain are classified as category 4 and grade II. While patients with tissue loss are classified as grade III, and category 5 and 6. **(Rutherford et al., 1997)**

Patients with lower extremity PAD exhibit significant variability in clinical presentation and in localization of disease withen the lower extremity vasculature **(Bosiers, et al, 2006)**

Patients may present with symptoms that range from intermittent claudication to rest pain or to tissue loss. The pattern of localization of vascular disease ranges from a lesion that is isolated to a single level in the lower extremity vasculature to lesions that present simultaneously at multiple levels. **(Murabito, et al, 1997)**

The risk factors that characterize disease of the infrapopliteal vasculature are similar to those that characterize aorto-iliac and femoropopliteal disease: advanced age, smoking, DM, hypertension, hyperlipidemia, male gender, MI and heart failure. In particular DM affects 63% to 91% of patients undergoing treatment for infrapopliteal PAD.

(Criqui, et al, 1992)

In spite of the treatment of critical limb ischemia (CLI) consumes significant amount of health care resources, Amputation remains a common procedure especially in diabetic patients. **(Allie et al., 2005)**

Infrapopliteal PAD may occur in isolation or simultaneously with proximal level disease. Patients with multilevel disease are frequently older, have multiple comorbidities, exhibit increased vascular compromise, and fair

worse after endovascular intervention than patients with isolated disease of the aortoiliac or femoropopliteal vasculature.

(Collins et al., 2007)

Revascularization may consist of endovascular therapy or surgical bypass. In general, Patients treated for severe infrapopliteal disease exhibit diminished long-term patency for both surgical bypass and endovascular therapy than patients with disease isolated to the more proximal vasculature**.**

(De Rubertis, et al, 2007)

In patients with rest pain, tissue loss and ulceration, angioplasty is now commonly regarded as the first line of therapy. Such patients have significant comorbid diseases and are at high risk from general anesthesia. Crural angioplasty has a very low associated morbidity and mortality.

(Norgren et al., 2007)

The endovascular treatment of multilevel disease is thought to result in worse outcomes compared with the treatment of single-level disease of the femoropopliteal or aorto-iliac vasculature, because each lesion has its own failure rate that results in an additive effect. In addition, patients with multilevel disease are frequently older, have more comorbidities, and have lower baseline ankle-brachial indices than patients with single-level disease**.** **(Conte, et al, 2001)**

A comparison between single-level interventions of the infrapopliteal vasculature and multilevel interventions involving the infrapopliteal vasculature is a point of importance as regarding the post operative outcome. **(Vraux, et al, 2006)**

Aim of the work

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The aim of this study is to compare the results of endovascular intervention for tibial disease combined with SFA lesions with that done for isolated tibial disease as regards primary patency , limb salvage and major amputation rate.

Review of the literature

Anatomy of The Arteries of the Lower Extremity

The artery which supplies the greater part of the lower extremity is the direct continuation of the external iliac. It runs as a single trunk from the inguinal ligament to the lower border of the Popliteus, where it divides into two branches, the **anterior** and **posterior tibial.** The upper part of the main trunk is named the **femoral,** the lower part the **popliteal.**

a. The Femoral Artery

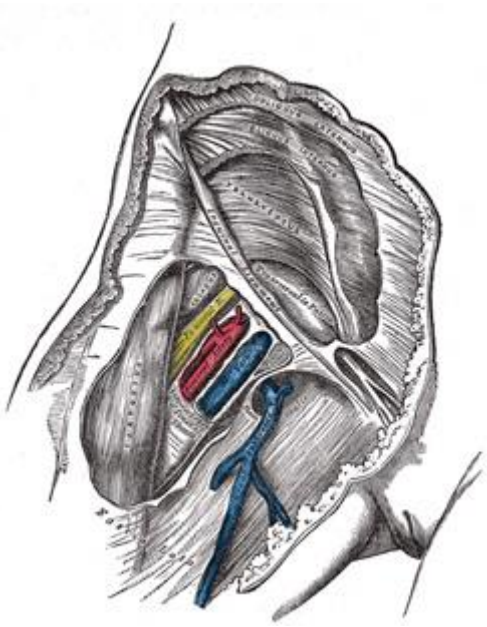


FIG. 1– Femoral sheath laid open to show its three compartments. ***(Quoted from Gray &Lewis, 2000).***

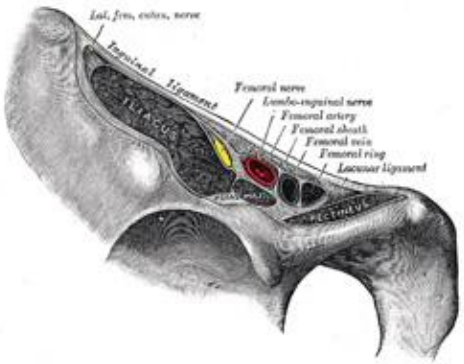


FIG. 2– Structures passing behind the inguinal ligament. ***(Quoted from Gray &Lewis, 2000).***

The **femoral artery** (Figs. 1, 2) begins immediately behind the inguinal ligament, midway between the anterior superior spine of the ilium and the symphysis pubis, and passes down the front and medial side of the thigh. It ends at the junction of the middle with the lower third of the thigh, where it passes through an opening in the Adductor magnus to become the popliteal artery.

The vessel, at the upper part of the thigh, lies in front of the hip-joint; in the lower part of its course it lies to the medial side of the body of the femur, and between these two parts, where it crosses the angle between the head and body, the vessel is some distance from the bone.

The first 4 cm. of the vessel is enclosed, together with the femoral vein, in a fibrous sheath—the **femoral sheath.** In the upper third of the thigh the femoral artery is contained in the **femoral triangle** (*Scarpa's triangle*), and in the middle third of

the thigh, in the **adductor canal** (*Hunter's canal*). **(Chung et al,2008)**

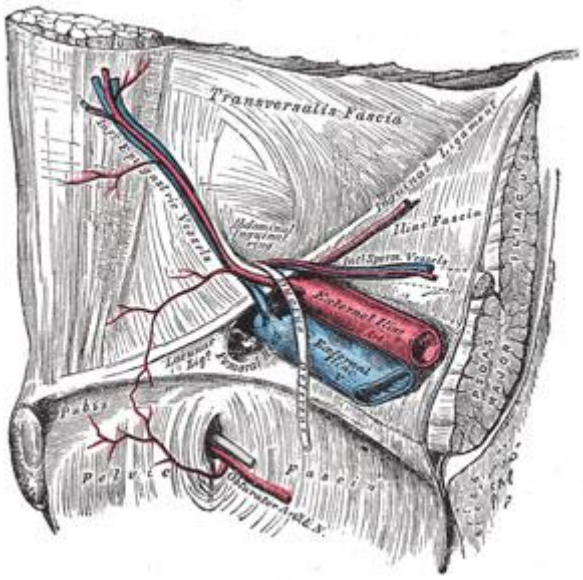


FIG. 3– The relations of the femoral and abdominal inguinal rings, seen from within the abdomen. Right side. ***(Quoted from Gray &Lewis, 2000).***

The **femoral sheath** (*crural sheath*) (Figs. 3) is formed by a prolongation downward, behind the inguinal ligament, of the fasciæ which line the abdomen, the transversalis fascia being continued down in front of the femoral vessels and the iliac fascia behind them.

The sheath assumes the form of a short funnel, the wide end of which is directed upward, while the lower, narrow end fuses with the fascial investment of the vessels, about 4 cm. below the inguinal ligament. It is strengthened in front by a band termed the **deep crural arch** .

The lateral wall of the sheath is vertical and is perforated by the lumboinguinal nerve; the medial wall is directed obliquely downward and lateralward, and is pierced by the great saphenous vein and by some lymphatic vessels. The sheath is divided by two vertical partitions which stretch between its anterior and posterior walls. **(Gray ,2000)**

The lateral compartment contains the femoral artery, and the intermediate the femoral vein, while the medial and smallest compartment is named the **femoral canal,** and contains some lymphatic vessels and a lymph gland imbedded in a small amount of areolar tissue.

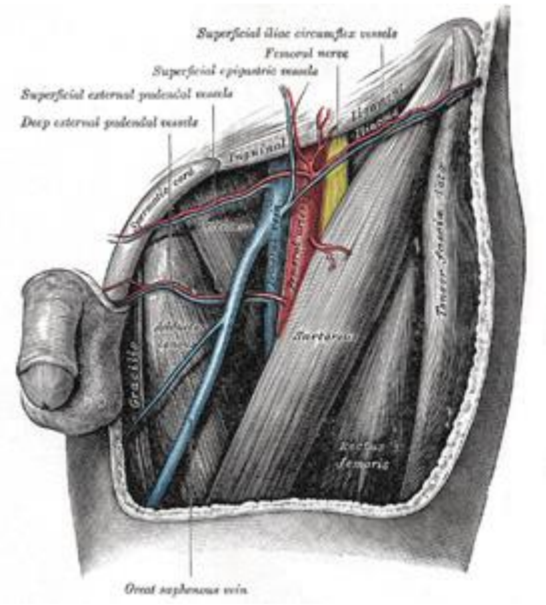


FIG. 4– The left femoral triangle. ***(Quoted from Gray &Lewis, 2000).***

Relations of the Femoral Artery.—In the *femoral triangle* (Fig. 4) the artery is superficial. *In front* of it are the skin and superficial fascia, the superficial subinguinal lymph glands, the superficial iliac circumflex vein, the superficial layer of the fascia lata and the anterior part of the femoral sheath.

(Williams et al,2000)

Behind the artery are the posterior part of the femoral sheath, the pectineal fascia, the medial part of the tendon of the Psoas major, the Pectineus and the Adductor longus. The artery is separated from the capsule of the hip-joint by the tendon of the Psoas major, from the Pectineus by the femoral vein and profunda vessels, and from the Adductor longus by the femoral vein.

The nerve to the Pectineus passes medialward behind the artery. On the *lateral* side of the artery, but separated from it by some fibers of the Psoas major, is the femoral nerve. The femoral vein is on the medial side of the upper part of the artery, but is behind the vessel in the lower part of the femoral triangle.

(*Gloviczki *et al,1994)

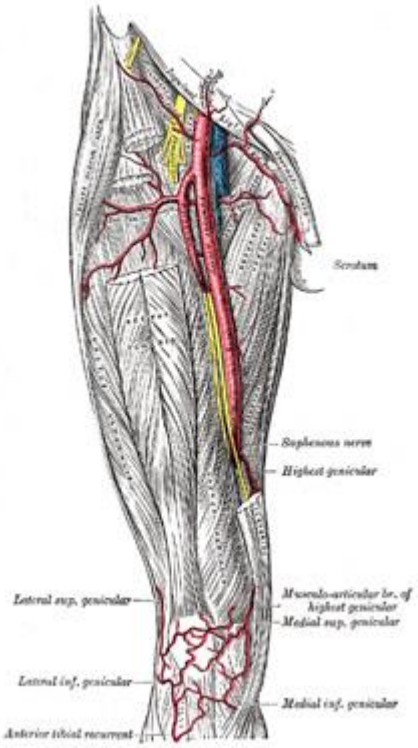


FIG. 5– The femoral artery. ***(Quoted from Gray &Lewis, 2000).***

In the *adductor canal* (Fig. 5) the femoral artery is more deeply situated, being covered by the integument, the superficial and deep fasciæ, the Sartorius and the fibrous roof of the canal; the saphenous nerve crosses from its lateral to its medial side. Behind the artery are the Adductores longus and magnus; in front and lateral to it is the Vastus medialis. The femoral vein lies posterior to the upper part, and lateral to the lower part of the artery. **(Teresa et al,2006)**

Peculiarities.—Several cases are recorded in which the femoral artery divided into two trunks below the origin of the profunda, and became reunited near the opening in the Adductor

magnus, so as to form a single popliteal artery. One occurred in a patient who was operated upon for popliteal aneurism.

(Gabrielli and Olave, 2002)

A few cases have been recorded in which the femoral artery was absent, its place being supplied by the inferior gluteal artery which accompanied the sciatic nerve to the popliteal fossa. The external iliac in these cases was small, and terminated in the profunda.

The femoral vein is occasionally placed along the medial side of the artery throughout the entire extent of the femoral triangle; or it may be split so that a large vein is placed on either side of the artery for a greater or lesser distance.

(Carla et al,2002)

b-The Popliteal Artery(A. Poplitea)

The ***popliteal artery*** (Fig. 6) is the continuation of the femoral, and courses through the popliteal fossa. It extends from the opening in the Adductor magnus, at the junction of the middle and lower thirds of the thigh, downward and lateralward to the intercondyloid fossa of the femur, and then vertically downward to the lower border of the Popliteus, where it divides into **anterior** and **posterior tibial arteries.**

(Hidalgo and shaw, 1986)

Relations:

In *front* of the artery from above downward are the popliteal surface of the femur (which is separated from the vessel by some fat), the back of the knee-joint, and the fascia covering the Popliteus. *Behind,* it is overlapped by the Semimembranosus above, and is covered by the gastrocnemius and Plantaris below.

In the middle part of its course the artery is separated from fasciæ by a quantity of fat, and is crossed from the lateral to the medial side by the tibial nerve and the popliteal vein, the vein being between the nerve and the artery and closely adherent to the latter. **(Ozer et al., 2005)**

On its *lateral* side, above, are the Biceps femoris, the tibial nerve, the popliteal vein, and the lateral condyle of the femur; below, the Plantaris and the lateral head of the Gastrocnemius. On its *medial* side, above, are the Semimembranosus and the medial condyle of the femur; below, the tibial nerve, the popliteal vein, and the medial head of the Gastrocnemius. The relations of the popliteal lymph glands to the artery are described above. **(Attinger et al., 1997)**

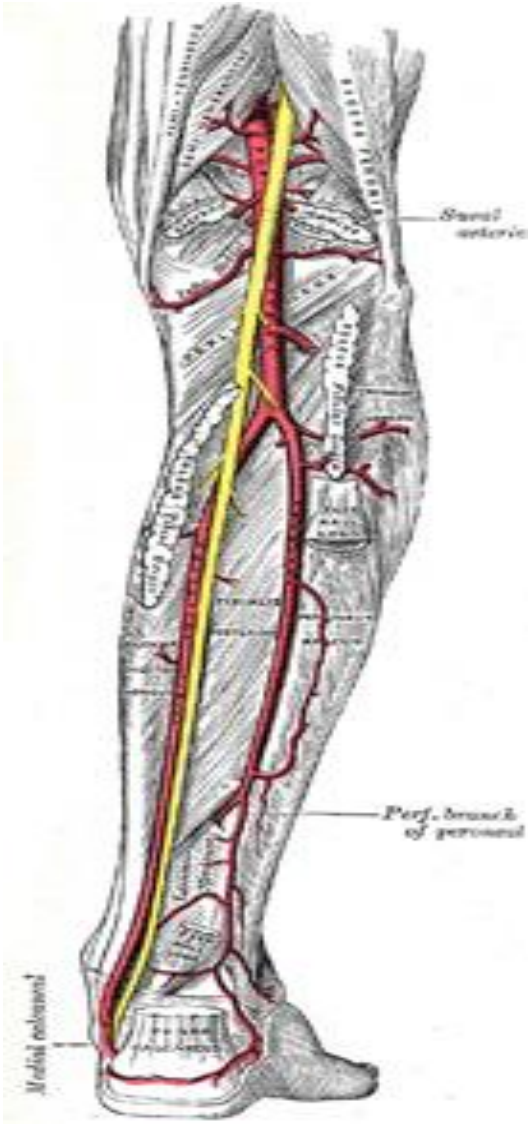


FIG. 6– The popliteal, posterior tibial, and peroneal arteries. ***(Quoted from Gray &Lewis, 2000).***

Peculiarities in Point of Division:

Day and Orme had one of the largest angiographic studies on the variations of the popliteal artery branching patterns. In 941 limbs (90.7%) of 1037 studied limbs, Day and Orme found that popliteal artery was divided as mentioned in the previous paragraph. **(Day and Orme, 2006)**

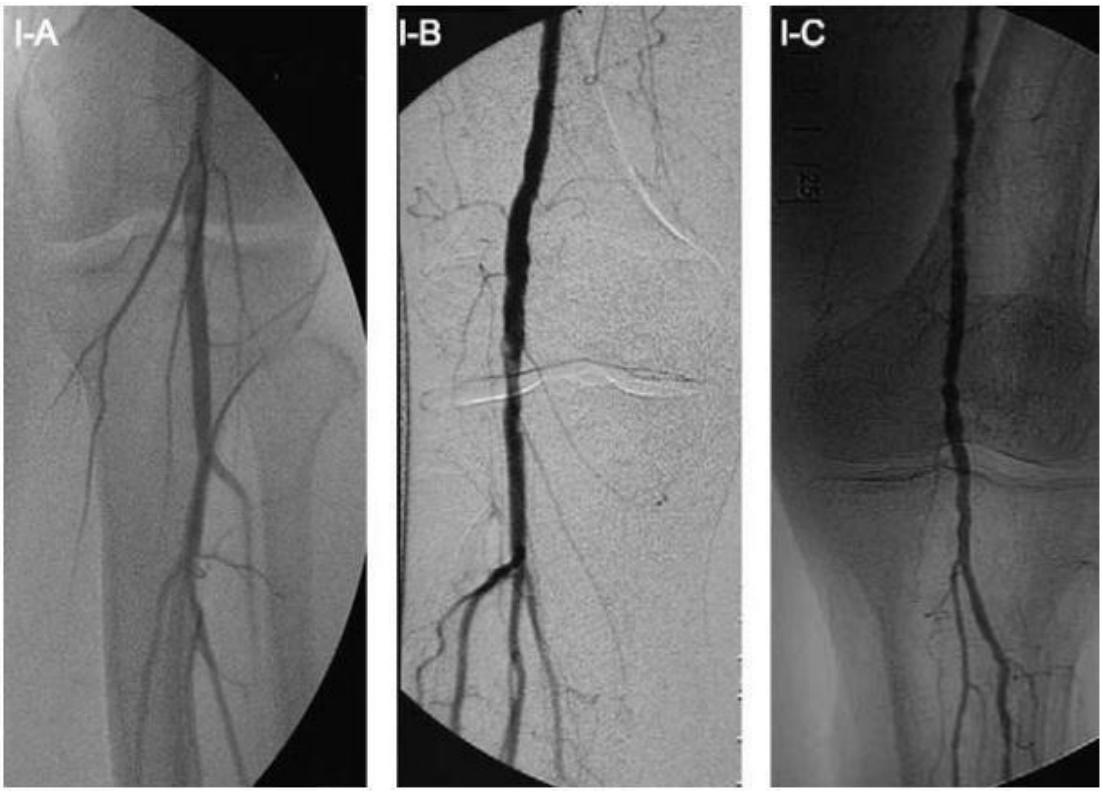


*Figure (7): shows popliteal branching patterns. I-A is the usual branching pattern. Type I-B the popliteal artery is seen to have a trifurcation. I-C PTA arises first and there is an anterior TPT. (Quoted from **Day and Orme, 2006**)*

Day and Orme found variations in popliteal branching pattern in 96 limbs (9.3%) of the 1037 studied limbs. The commonest variation is the high origin of the ATA in 47 limbs (4.5%) or trifurcation of the popliteal artery in 33 limbs (3.2%) with ATA,

PTA and PR arising together with no true TPT. Eleven limbs (1.1%) had high origin of PTA and two limbs (0.2%) had a high origin of the PRA, as shown in figure 7.

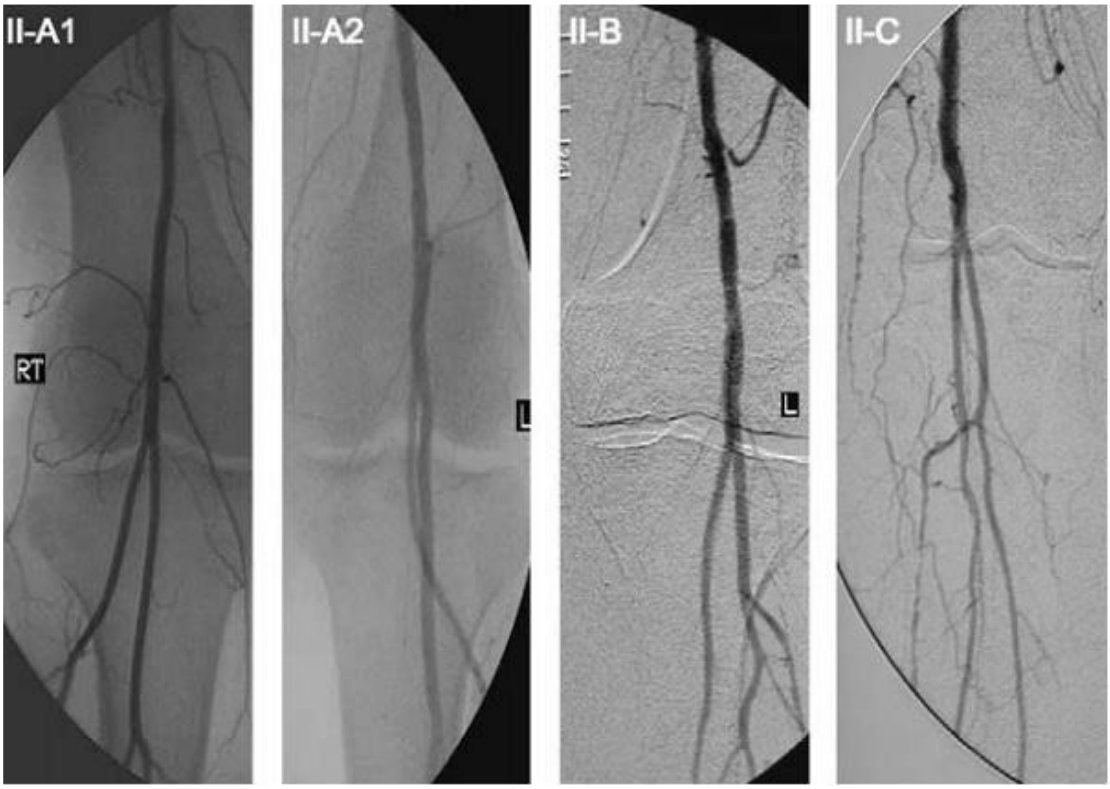


Figure (8): shows another popliteal artery branching patterns. In II-A ATA arises at the level of the tibial plateau, then in II-A1, it passes laterally or in II-A2 it initially passes medially then turns laterally to continue its normal course. II-B PTA arises at the level of the tibial plateau. II-C PRA arises at the level of the tibial plateau and ATA/PTA arised from a common trunk. (Quoted from ***Day and Orme, 2006****)*

In the same study, Day and Orme reported the distal branching pattern of tibial vessels in 662 limbs. 5 limbs (0.8%) had a hypoplastic PTA and the remaining 2 limbs (0.2%) had either a hypo-plastic ATA or hypoplasia of both ATA and PTA .

(Day and Orme, 2006)

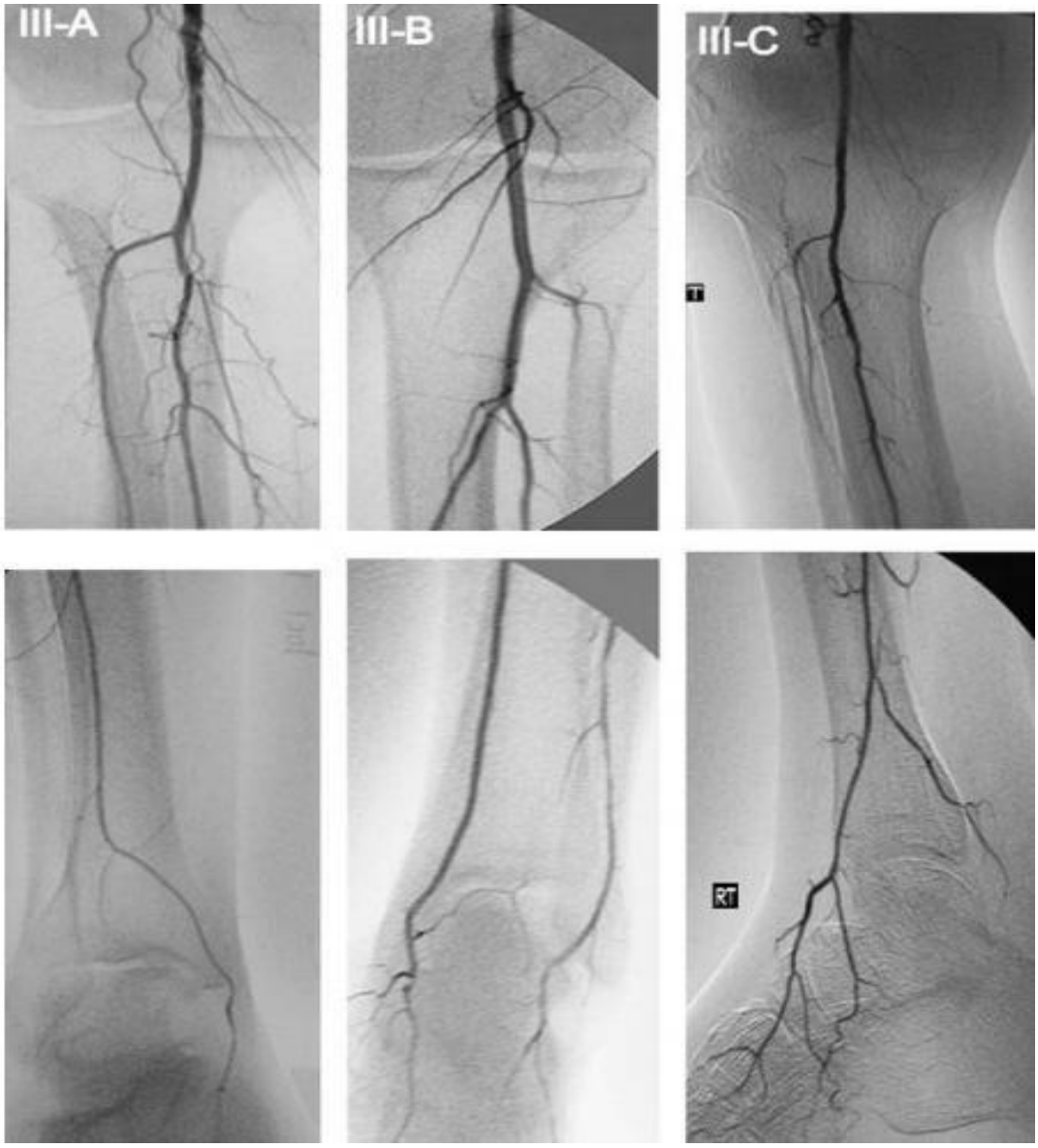


Figure (9): shows Type III Tibial vessel patterns. III-A PTA is hypoplastic or absent and the distal PTA arises from PRA at the ankle. III-B ATA is absent or hypoplastic and DPA arises from PRA at the ankle. III-C both ATA and PTA are hypoplastic or absent and both DPA and distal PTA arise from PRA at the ankle. (Quoted from ***Day and Orme, 2006****)*

The Anterior Tibial Artery

The anterior tibial artery (Fig.10) commences at the bifurcation of the popliteal, at the lower border of the Popliteus, passes forward between the two heads of the tibialis posterior, and through the aperture above the upper border of the interosseous membrane, to the deep part of the front of the leg: it lies here close to the medial side of the neck of the fibula.

It then descends on the anterior surface of the interosseous membrane, gradually approaching the tibia; at the lower part of the leg it lies on this bone, and then on the front of the ankle-joint, where it is more superficial, and becomes the dorsalis pedis. **(Williams et al., 2000)**

Relations:

In the upper two-thirds of its extent, the anterior tibial artery rests upon the interosseous membrane; in the lower third, upon the front of the tibia, and the anterior ligament of the ankle-joint. In the upper third of its course, it lies between the tibialis anterior and extensor digitorum longus; in the middle third between the tibialis anterior and extensor hallucis longus.

At the ankle it is crossed from the lateral to the medial side by the tendon of the extensor hallucis longus, and lies between it and the first tendon of the extensor digitorum longus. It is

covered in the upper two-thirds of its course, by the muscles which lie on either side of it, and by the deep fascia; in the lower third, by the integument and fascia, and the transverse and cruciate crural ligaments.

The anterior tibial artery is accompanied by a pair of venæ comitantes which lie one on either side of the artery; the deep peroneal nerve, coursing around the lateral side of the neck of the fibula, comes into relation with the lateral side of the artery shortly after it has reached the front of the leg; about the middle of the leg the nerve is in front of the artery; at the lower part it is generally again on the lateral side. **(Williams et al., 2000)**

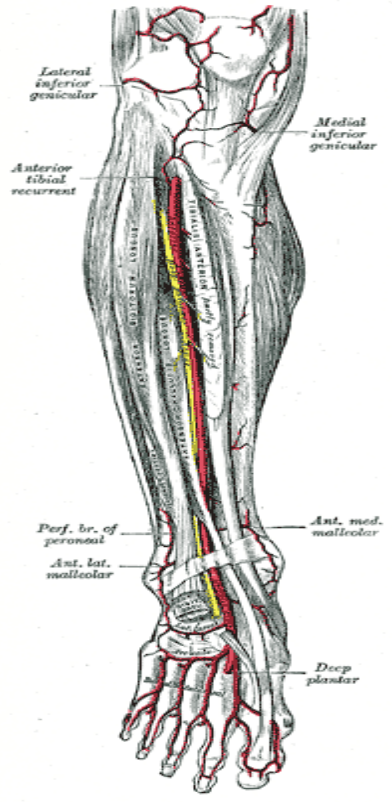


Figure (10): *Anterior tibial and dorsalis pedis arteries* ***(Quoted from Gray & Lewis 2000).***

Course:

The artery occasionally deviates toward the fibular side of the leg,regaining its usual position at the front of the ankle. In rare instances the vessel has been found to approach the surface in the middle of the leg, being covered merely by the integument and fascia below that point. **(Gray & Lewis, 2000)**

Branches:

The branches of the anterior tibial artery are:

- Posterior Tibial Recurrent.
- Fibular.
- Anterior Tibial Recurrent.
- Muscular.
- Anterior Medial Malleolar.
- Anterior Lateral Malleolar.

The fibular artery is sometimes derived from the anterior tibial,sometimes from the posterior tibial. It passes lateralward, around the neck of the fibula, through the soleus, which it supplies, and ends in the substance of the peroneus longus.

(Gray & Lewis, 2000)

The arteries around the ankle-joint anastomose freely with one another and form net-works below the corresponding malleoli. The medial malleolar network is formed by the anterior medial malleolar branch of the anterior tibial, the medial tarsal branches

of the dorsalis pedis, the posterior medial malleolar and medial calcaneal branches of the posterior tibial and branches from the medial plantar artery.

The lateral malleolar net-work is formed by the anterior lateral malleolar branch of the anterior tibial, the lateral tarsal branch of the dorsalis pedis, the perforating and the lateral calcaneal branches of the peroneal, and twigs from the lateral plantar artery. **(Chung et al, 2008)**

The Arteria Dorsalis Pedis (Dorsalis Pedis Artery)

The arteria dorsalis pedis (Fig.10) the continuation of the anterior tibial,passes forward from the ankle-joint along the tibial side of the dorsum of the foot to the proximal part of the first intermetatarsal space, where it divides into two branches, the first dorsal metatarsal and the deep plantar .

(Valentine et al,2003)

Relations:

This vessel, in its course forward, rests upon the front of the articular capsule of the ankle-joint, the talus, navicular, and second cuneiform bones, and the ligaments connecting them, being covered by the integument, fascia and cruciate ligament, and crossed near its termination by the first tendon of the Extensor digitorum brevis. On its tibial side is the tendon of the

Extensor hallucis longus; on its fibular side, the first tendon of the Extensor digitorum longus, and the termination of the deep peroneal nerve. It is accompanied by two veins.

(Valentine et al, 2003)

Position:

This artery frequently curves lateralward, lying lateral to the line between the middle of the ankle and the back part of the first interosseous space.

Branches:

The branches of the arteria dorsalis pedis are:

- Lateral Tarsal.
- Medial Tarsal.
- Arcuate.
- First Dorsal Metatarsal.
- Deep Plantar . **(Gray & Lewis, 2000)**

The Posterior Tibial Artery

The posterior tibial artery(Fig. 11) begins at the lower border of the Popliteus, opposite the interval between the tibia and fibula; it extends obliquely downward, and, as it descends, it approaches the tibial side of the leg, lying behind the tibia, and in the lower part of its course is situated midway between the medial malleolus and the medial process of the calcaneal

tuberosity. Here it divides beneath the origin of the Adductor hallucis into the medial and lateral plantar arteries.

(Boallack, 2009)

Relations:

The posterior tibial artery lies successively upon the Tibialis posterior,the Flexor digitorum longus, the tibia, and the back of the ankle-joint. It is covered by the deep transverse fascia of the leg, which separates it above from the Gastrocnemius and Soleus; at its termination it is covered by the Abductor hallucis.

In the lower third of the leg, where it is more superficial, it is covered only by the integument and fascia, and runs parallel with the medial border of the tendo calcaneus. It is accompanied by two veins, and by the tibial nerve, which lies at first to the medial side of the artery, but soon crosses it posteriorly, and is in the greater part of its course on its lateral side.

Behind the medial malleolus, the tendons, bloodvessels, and nerve are arranged, under cover of the lacunate ligament, in the following order from the medial to the lateral side: the tendons of the Tibialis posterior and Flexor digitorum longus, lying in the same groove, behind the malleolus, the former being the more medial.

Next is the posterior tibial artery, with a vein on either side of it; and lateral to the vessels is the tibial nerve; about 1.25 cm. nearer the heel is the tendon of the Flexor hallucis longus. **(Valentine and Wind, 2003)**

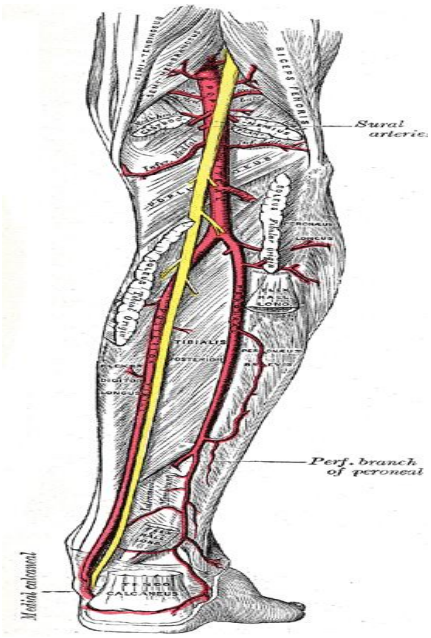


Figure (11): The posterior tibial, and peroneal arteries ***(Quoted from Gray &Lewis, 2000).***

Branches:

The branches of the posterior tibial artery are:

- Peroneal.
- Nutrient.
- Muscular.
- Posterior Medial Malleolar.
- Communicating.
- Medial Calcaneal **(Gray & Lewis, 2000)**

The peroneal artery (a. peronæa)

It is deeply seated on the back of the fibular side of the leg. It arises from the posterior tibial, about 2.5 cm. below the lower border of the Popliteus, passes obliquely toward the fibula, and then descends along the medial side of that bone,contained in a fibrous canal between the tibialis posterior and the flexor hallucis longus, or in the substance of the latter muscle.

It then runs behind the tibiofibular syndesmosis and divides into lateral calcaneal branches which ramify on the lateral and posterior surfaces of the calcaneus. It is covered, in the upper part of its course, by the soleus and deep transverse fascia of the leg; below, by the Flexor hallucis longus.

(Valentine and Wind, 2003)

Peculiarities in Origin:

The peroneal artery may arise 7 or 8 cm. below the Popliteus, or from the posterior tibial high up, or even from the popliteal. Its size is more frequently increased than diminished; and then it either reinforces the posterior tibial by its junction with it, or altogether takes the place of the posterior tibial in the lower part of the leg and foot, the latter vessel only existing as a short muscular branch.

In those rare cases where the peroneal artery is smaller than usual, a branch from the posterior tibial supplies its place; and a branch from the anterior tibial compensates for the diminished anterior peroneal artery.

(Gray & Lewis, 2000)

Branches:

The branches of the peroneal are:

- Muscular.
- Nutrient.
- Perforating.
- Communicating.
- Lateral Calcaneal ***(Chung, 2008).***

Blood supply of the ankle and the foot

The foot blood supply depends on the irrigation from the anterior and posterior tibial arteries, which give off branches to the dorsum and sole of the foot, respectively as shown in figure 12. **(Gabrielli and Olave, 2002)**

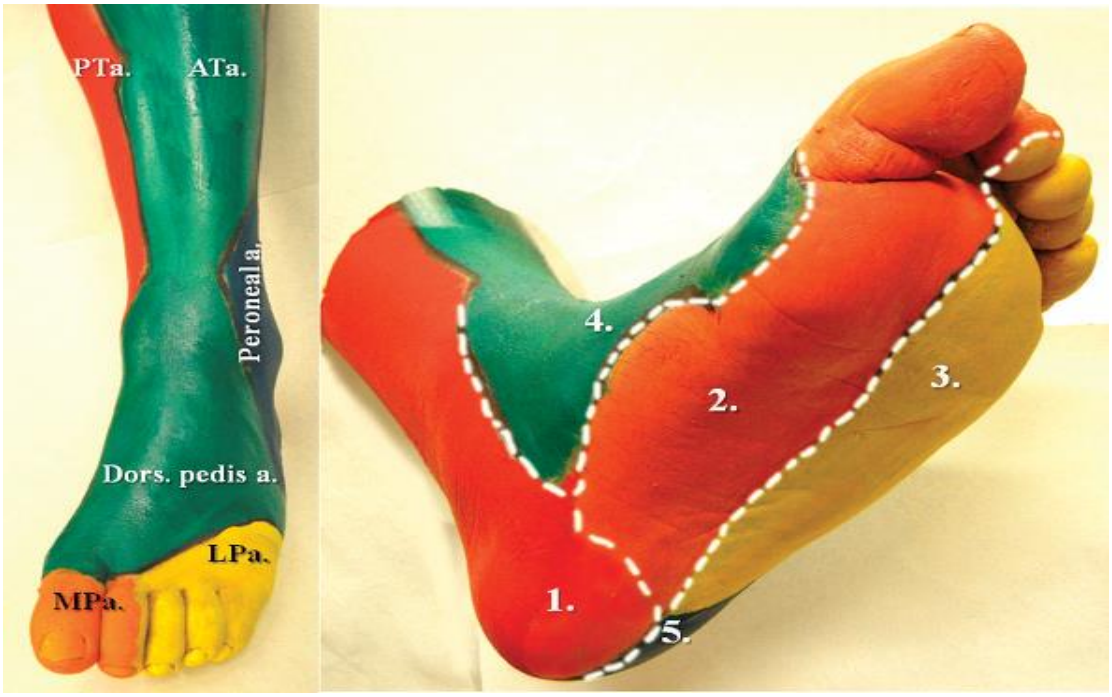


Figure (12)Territorial blood supply of the ankle and foot (quoted from **Alexandrescu et al.,2008**)

The angiosome

The angiosome is an important anatomic concept that was confirmed by Nakajima et al in 1981 when he injected prostaglandin (E l) into selected arteries. This caused a localized flush in the skin that corresponded with the cutaneous vascular territories described by Manchot and Salmon.

(Nakajima et al, 1981)

Taylor developed the understanding of the angiosome concept. He defined the angiosome as a block of tissues (skin, subcutaneous tissue, fascia, muscle, and bone) fed by a named artery. **(Taylor and palmer, 1990)**

Mc gregor and Morgan showed that areas between different angiosomes were dynamic in which it served as a conduit, so that a territory could supply its neighboring territory with blood flow if the latter loses its own. **(Mc gregor and Morgan, 1973)**

Territorial blood supply of the ankle

The anterior tibial artery supplies the anterior aspect of the ankle joint via the anterior lateral malleolar and the anterior medial malleolar arteries. The anterior lateral malleolar artery anastomoses with the peroneal artery's perforating branch laterally and with the lateral tarsal artery distally. The anterior medial malleolar artery joins the posterior medial malleolar artery of the posterior tibial artery over the medial malleolus.

(Attinger et al., 1997)

The posterior tibial artery and peroneal artery supply the posterior aspect of the ankle and the heel via their calcaneal branches, and they inter communicate with each other via 3 branches for each, as shown in figure 12.

(Hidalgo and shaw, 1986)

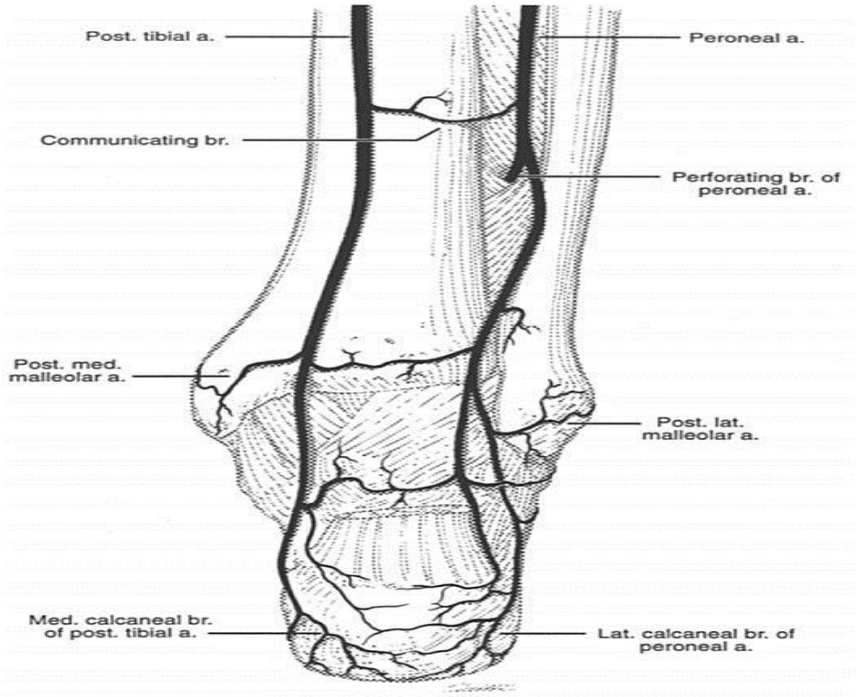


Figure (13): shows the blood supply of the heel (back view). (Quoted from **Attinger et al., 1997***)*

Territorial blood supply of the foot

Dorsalis paedis artery supplies the dorsum of the foot via lateral tarsal artery, two medial tarsal arteries, and arcuate artery proximally. In turn, Arcuate artery gives off the second, third, and fourth dorsal metatarsal arteries, each of which divides into two dorsal digital branches for the adjoining each toe, as shown in figure 6. The two medial tarsal arteries traverse medially to anastomose with the superficial branch of the medial plantar artery**.** **(Attinger et al., 1997)**

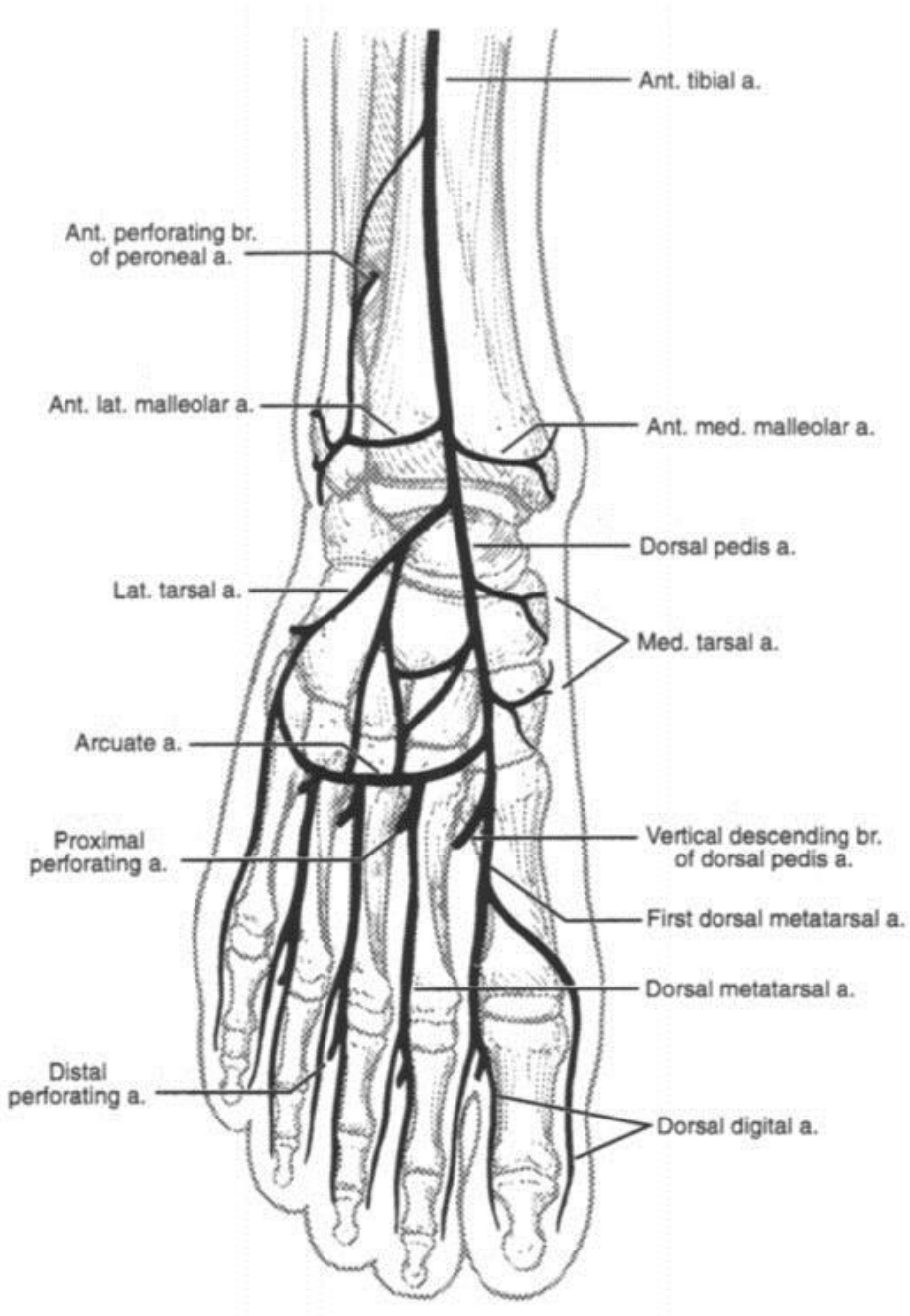


Figure (14): shows the blood supply of the dorsum of the foot. (Quoted from **Attinger et al., 1997***)*

Distally, the dorsalis pedis gives off the first dorsal metatarsal artery (FDMA) and then it dives into the proximal first intermetatarsal space to join the lateral plantar artery to form the plantar arch. **(Attinger et al., 1997)**

The FDMA provides blood supply to the first interosseus muscle as well as the skin overlying it, the first web space, and lateral dorsal aspect of the hallux and medial dorsal aspect of the second digit. **(Attinger et al., 1997)**

Gabrielli and Olave studied the dorsal metatarsal arteries in 50 feet of 25 Brazilians cadavers. They found that the FDMA originated from the dorsalis pedis artery exclusively in 86% of cadavers. The proximal perforating branches of plantar metatarsal arteries contributed partially or totally in the formation of the second DMA in 90%, the third DMA in 92%, and the fourth DMA in 86 %. **(Gabrielli and Olave, 2002)**

The posterior tibial artery supplies the plantar surface of the foot via the medial and lateral plantar arteries. The medial plantar artery shares the dorsalis pedis and the FDMA to supply the medial aspect of the foot and the hallux respectively.

The lateral plantar artery shares the lateral tarsal artery and the arcuate artery to supply the lateral aspect of the foot. The deep plantar arch is formed by the transverse portion of the lateral plantar artery and perforating branch of the dorsalis pedis artery, as shown in figure 14. **(Attinger et al., 1997)**

The plantar arch gives off three perforating and four plantar metatarsal branches, and numerous branches that supply the skin, fasciae and muscles in the sole. Three perforating branches anastomose with the 2, 3, and 4 dorsal metatarsal arteries.

Four plantar metatarsal arteries, each divides into two plantar digital arteries, supplying the adjacent digital aspects. Near its division, each plantar metatarsal sends a distal perforating branch dorsally to join a dorsal metatarsal artery.

(You-Gang Chen et al., 1998)

Ozer et al had studied the deep plantar arch in 50 adult cadaveric feet and he found 3 types of the deep plantar arch. Type I in which dorsalis pedis artery was the predominant artery in formation of the deep plantar arch and this type was found in 48% of the studied feet.

Type II in which lateral plantar artery was the predominant artery in formation of the deep plantar arch and this type was found in 38% of the studied feet. Type III in which both arteries contributed equally in formation of the deep plantar arch and this type was found in 14% of the studied feet.

(Ozer et al., 2005)

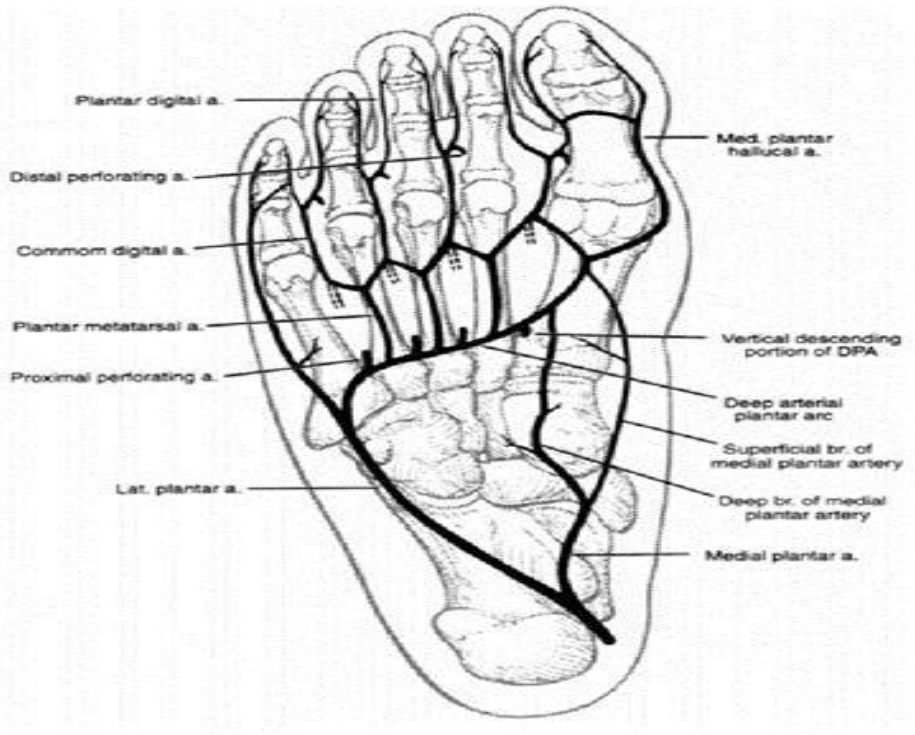


Figure (15): shows Blood supply of the sole of foot (Quoted from **Attinger et al., 1997***) a.; artery, lat.; lateral, br; branch, DPA; dorsalis paedis artery*

Pathophgysiology

Pathophgysiology

Arteriosclerosis may be defined as “a space occupying lesion or plaque of the inner coat of larger arteries that is focal, has a pattern of occurrence, is composed of an excess of fat, of an increased number of artery wall and inflammatory cells and their connective tissue products, and that may show calcification and ulceration, narrows the arterial lumen, may obstruct blood flow through the artery and may be associated with a local thrombus.” **(Stary et al., 1995)**

Atherosclerosis is a systemic, multifocal disease leading to various symptoms and clinical events including cardiovascular disease, cerebrovascular disease, and peripheral arterial disease. **(Oksjoki et al., 2007)**

Atherosclerotic-related cardiovascular disease (CVD) is the leading cause of death in every region of the world except sub-Saharan Africa, and is a systemic progressive process affecting multiple vascular territories. **(Bonow et al.,2002)**

Atherosclerotic lesions are formed in early childhood and increase with age. So diffuse intimal thickenings have been identified in the atherosclerotic-prone areas of coronary arteries as early as 36 weeks' gestation. **(Nakashima et al.,2002)**

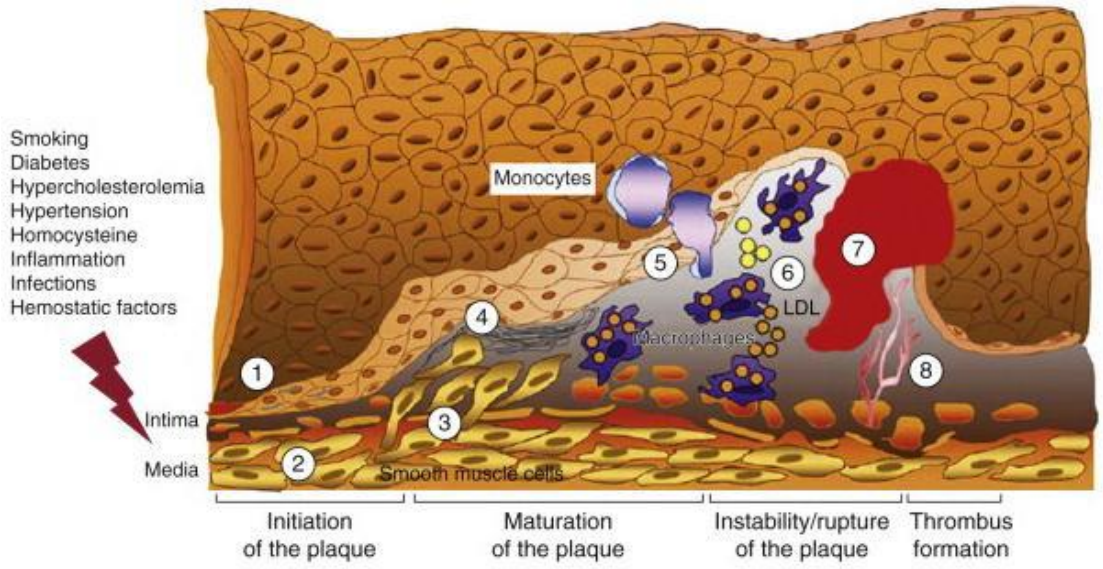


*Figure (16): shows Plaque formation: 1, Endothelial dysfunction; 2, vascular smooth muscle cell (VSMC) hypertrophy; 3, migration and proliferation of VSMCs; 4, matrix elaboration; 5, expression of adhesion molecules and migration of monocytes; 6, uptake of low-density lipoprotein (LDL) and formation of foam cells; 7, thrombus formation; 8, angiogenesis and neovascularization. (***Liapis et al., 2007***)*

Staging: The American Heart Association proposed six stages for human atherosclerotic lesions based on histologic composition and structure of the plaque. Type I, type II and type III lesions are considered early lesions, While Types IV, V, and VI are the advanced atherosclerotic lesions.

- Type I lesions are microscopically characterized by an increase in the number of intimal macrophages and the accumulation of lipid droplets within to form foam cells.

- Type II lesions are the first lesions to be visualized grossly and include fatty streaks(layers of foam cells, lipid-containing vascular SMCs and higher numbers of macrophages).
- Type III lesions are moreover characterized by pools of extracellular lipid droplets dispersed among the layers of vascular SMCs and foam cells.
- Type IV lesions have well-defined lipid core (atheromas) which is formed by the confluence of the lipid pools.
- Type V lesions develop a prominent fibrous connective tissue (the fibrous cap), which generally begin to appear in the fourth decade of life and can cause significant narrowing of the arterial lumen, producing symptoms.

- Type VI lesions (complicated lesions), which are responsible for the majority of morbidity and mortality from atherosclerosis, occur at the time of intimal surface disruption.

(stary et al.,1994)

Atherosclerosis is considered as an intramural chronic inflammation resulting from interactions between modified

lipoproteins, monocyte-derived macrophages, lymphocytes, and the normal cellular elements of the arterial wall.

(langheinrich et al,2005)

The superficial femoral artery is a common site for infrainguinal atherosclerotic disease, particularly the portion of the superficial femoral artery that lies within the adductor canal of the thigh **.** ***(Davies et al.,2005***)

While patients with atherosclerotic disease confined to the infrapopliteal arteries may be asymptomatic due to the excellent collateral network which develops between tibial arteries; one patent tibial artery is often sufficient to keep a patient free from ischaemic symptoms. **(Ray et al. , 2009)**

When these patients present with CLI they often have severe, extensive three-vessel disease and only 20–30% have a simple, focal lesion with good distal runoff .The lesions of atherosclerosis occur principally within the innermost layer of the artery wall, the intima.The number and severity of lesions are directly related to known cardiovascular risk factors.

(Mc Gill et al., 2008)

Risk Factors:

The practice guidelines for the diagnosis and treatment of PAD developed by the American College of Cardiology (ACC) and the American Heart Association (AHA) recognize that coronary heart disease (CHD) and PAD share the common risk factors . **(Hirsch et al.,2005)**

AHA prevention conference statement in 1999 classified risk factors into three categories: (1) conventional risk factors, which appear to have a direct causal role in atherogenesis; (2) predisposing factors, which mediate some risk through the causal factors but may also have independent effects; and (3) conditional risk factors, which have "an association with an increased risk for CAD. **(Grundy et al.,2002)**

Conventional risk factors

1. Hypercholesterolemia

Saturated fats became known to be associated with an increased incidence of atherosclerosis when it was found that they elevate the concentration of plasma cholesterol. Increased dietary cholesterol generally results in an increase in LDL cholesterol levels, with a lesser increase in HDL cholesterol levels.

As the role of these two lipoproteins in atherogenesis becomes clearer, it can be stated that elevated HDL levels appear to be protective, whereas the reverse is true for elevated LDL levels.

(Marinou et al. , 2010)

2. Hypertension

The means by which hypertension induces atherogenesis are not clear, although there are many humoral mediators of blood pressure which may participate in this process. For example, renin and other hypertensive agents may induce cellular changes that lead to atherogenesis.

Angiotensin II (AII), the principal product of the rennin angiotensin system, is a potent vasoconstrictor and may contribute to elevated blood pressure. Interestingly, AII can increase the activity of smooth-muscle lipoxygenases, which can participate in the oxidation of LDL and augment the inflammatory response. **(Jaffe,2004)**

3. Cigarette Smoking

Cigarette smoke is toxic and contains around 4000 chemicals of which nicotine and carbon monoxide are the most significant. Because of the greater affinity of carbon monoxide for hemoglobin over that of oxygen, smoking results in alterations to oxygen transport with vasoconstriction and injury to the vascular wall by the combined action of nicotine and

carbon monoxide, with increased thrombophilia that raises the risk of thrombosis over the atheromatous plaques.

(Pearson et al.,2003)

4. Diabetes

Diabetes mellitus is the most important risk factor for large vessel atherosclerotic occlusive disease and PAD is severe and often extensive, with involvement of the proximal lower limb (femoral and popliteal) arteries (as in non-diabetics) but with predominant distal disease affecting tibial and peroneal arteries. In comparison with non-diabetic patients, diabetics have a two- to four-fold increase in risk of developing intermittent claudication. **(Razani et al., 2008)**

Metabolic syndrome found in 50% of patients with peripheral vascular disease. These patients present with more advanced disease and have poorer symptomatic and functional outcomes compared with those patients without Metabolic syndrome.

(Smolock et al., 2012)

Therefore, to prevent micro- and macrovascular complications, like PVD, in type-1 and type-2 diabetes, intensive therapy, targeting glycemia and all other modifiable cardiovascular risk factors, should be initiated as soon after diagnosis as possible and maintained in a safe way throughout life.

(Huysman and Mathieu,2009)

peripheral arterial disease (PAD) is present in up to 50% of the patients with a diabetic foot ulcer and was an independent risk factor for amputation. The International Working Group on the Diabetic Foot therefore established a multidisciplinary working group to evaluate the effectiveness of revascularization of the ulcerated foot in patients with diabetes and PAD.

(Hinchliffe et al., 2012*)*

In diabetic patients with PAD , the outcome of both open surgery and endovascular treatment is broadly spoken the same for the endpoints ulcer healing and limb salvage and is between 78% and 85%. **(Reekers and Lammer J., 2012)**

PREDISPOSING RISK FACTORS

Predisposing risk factors for atherosclerosis are those that confer their risk through conventional factors and through potentially independent effects. Those that are nonmodifiable include advanced age, gender (male sex; postmenopausal women), family history and genetics, and race (eg, blacks) and ethnicity (eg, non-Hispanic blacks).

Those that are modifiable include overweight and obesity, physical inactivity, insulin resistance (even without

diabetes), and socioeconomic-behavioral factors such as social isolation, depression, type A personality, work, and family stress. Recommended practice is to Encourage lifestyle changes such as diet and exercise. **(Norgren et al .,2007)**

1. Obesity and sedentary lifestyle

Increased dietary fat intake and body fat are associated with an increased risk for ischemic heart disease . Upper abdominal obesity is associated with abnormal postheparin plasma lipoprotein lipase and hepatic lipase activities. Elevated fibrinogen level, also an independent risk factor for atherosclerosis, correlates with upper abdominal obesity.

(Marinou et al. , 2010)

2. Homocysteine

Elevation in homocysteine levels is strongly associated with the premature development of atherosclerosis in peripheral arteries and increases the risk for approximately two fold. Homocysteine is a sulfurcontaining amino acid at a level of about 5–15 μmol/l in healthy persons. Hyperhomocysteinemia is a risk factor for PAD in men and in young women.

(Razani et al., 2008)

3. Genetics and immunity:

Previous studies have implicated the involvement of the immune system in atherosclerosis formation and progression. Animal models have been used to test the contributions of components of the immune system . **(Zhang et al, 1992)**

Cellular involvement of macrophages was found to be important in the formation and progression of atherosclerosis in animal models. **(Nakashima et al, 1994)**

In addition, various immune-related genes have been examined in an atherosclerosis animal model, and genes such as *CXCR6, CXCL10, CXCR3* and *CXCL16/scavenger receptor* have been shown to be involved in the progression of atherosclerosis in animal models. **(Heller et al.,2006) (Aslanian and Charo ,2006)**

In humans, many immune cells such as macrophages, lymphocytes, mast cells, and T cells are found in atherosclerosis. **(Hansson et al., 2006).**

4. Fibrinogen

Fibrinogen, the substrate of thrombin, had been associated with cardiovascular disease in the first prospective trial by The Gothenburg Heart Study in 1984 .

(Wilhelmsen et al .,1984)

5. Novel or emerging factors

There are many factors which suspected to be involved in atherosclerosis such as inflammatory marker, creatinine, infectious agents, haemostatic factors….etc.

(Owens and Conte, 2010)

Assessment

Assessment of chronic lower limb ischemia

Peripheral arterial disease (PAD) is part of a global vascular problem of diffuse atherosclerosis. PAD patients die mostly of cardiac and cerebrovascular-related events and much less frequently due to obstructive disease of the lower extremities, Yet patients with critical rest limb ischemia or severe progressive claudication need to be treated with revascularization to minimize the chance of limb loss, reduce symptoms, and improve quality of life as PAD affects 12%–14% of the general population and its prevalence increases with age affecting up to 20% of patients over the age of 75.

(Shammas. 2007).

CLINICAL MANIFESTATIONS

Classifying the PAD patient

1. **Asymptomatic PAD:**

Asymptomatic PAD is typically suspected by clinical examination of the lower extremity pedal pulses. The ankle brachial index (ABI) is a simple test that can confirm the presence of disease. An ABI <0.9 is abnormal and indicates PAD. An ABI between 0.7 and 0.9 is considered mild disease, 0.5 and 0.69 is moderate disease, and less than 0.5 is severe disease.

2. Intermittent claudication (IC)

IC is defined as discomfort in the calf muscles with exertion that resolves after a few minutes of rest. IC is present in 5% of men and 2.5% of women over the age of 60**.**

(Shammas. 2007)

3. Chronic limb ischemia

Chronic limb ischemia defined as pain in the lower extremity at rest or ulceration with and without tissue necrosis.

4. Acute limb ischemia (ALI)

ALI occurs within hours of presentation and is associated with rest limb pain and a pulseless, painful foot where the vessel is typically occluded with a thrombus that has occurred on top of mild to severe lesions where plaque rupture is followed by in situ thrombosis or migration of a clot from a proximal location and Collaterals are generally minimal or none so management is an emergency to save the limb.

Critical limb ischemia (CLI):

Critical limb ischemia (CLI): is a manifestation of peripheral arterial disease (PAD) that describes patients with typical chronic ischemic rest pain or patients with ischemic skin lesions, either ulcers or gangrene. This term is used in relation to patients with chronic ischemic disease, defined as the presence

of symptoms for more than 2 weeks. Rutherford baker scale can be used to assess the severity of lower limb ischemia (table- 1). **(Norgren et al. , 2007)** .

If not revascularized, CLI patients are at risk for limb loss and for potentially fatal complications from the progression of gangrene and the development of sepsis.

(**Lumsden et al., 2009).**

Grade	**Category**	**Clinical description**
0		0 Asymptomatic
I		1 Mild claudication
		2 Moderate claudication
		3 Severe claudication
II		4 Ischemic rest pain
		5 Minor tissue loss; nonhealing ulcers
III		6 Major tissue loss above the metatarsal limb no longer salvageable

Table 1: Rutherford - Baker scale of severity of peripheral arterial disease **(Hirsh et al. , 2006)**.

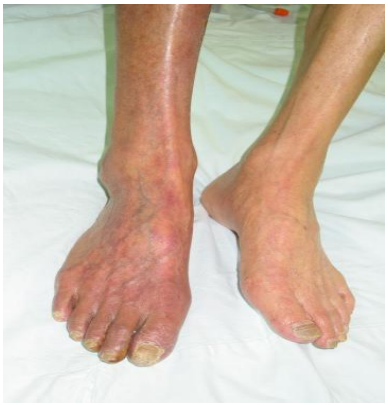


figure (17) critical limb ischaemia

PAIN

Ischemic rest pain is typically described as burning, dysesthetic pain,usually worse in the distal foot and in the toes and usually most severe at night.Rest pain is generally intolerably severe, aggravated by elevation, and relieved with dependency .

The pain occurs or worsens with reduction of perfusion pressure: leg elevation with loss of the supplemental effects of gravity on blood flow. Because of the intolerable, persisting pain, sleep becomes impossible for most of the patients, causing a further decline of their general physical and psychologic conditions.

Rest pain usually occurs at night when the limb is no longer in a dependent position, wakes the patients and forces them to get up or take a short walk to obtain partial relief from the dependent position.

Patients with ischemic pain often sleep in sitting position or with their ischemic leg dangling over the side of the bed. As a consequence of the need for prolonged dependent position of the ischemic leg, ankle and foot edema develop, aggravating foot pain and ischemic lesions. **(Hirsh et al. , 2006)**

In the most severe cases of CLI, rest pain is continuous, with episodes lasting minutes to hours but with constant diffuse pain remaining in between. Often the pain cannot be adequately relieved from foot dependency and responds only to opiates.

(Norgren et al. , 2007)

ULCERS AND GANGRENE

In diabetic patients with diabetic neuropathy, CLI does not progress from rest pain to tissue loss but the initial presentation is with a neuro ischemic ulcer or gangrene. Non diabetic gangrene and ulcers usually affect the digits or the pressure points (the heel in bedridden patients) and may extend to the distal parts of the foot.

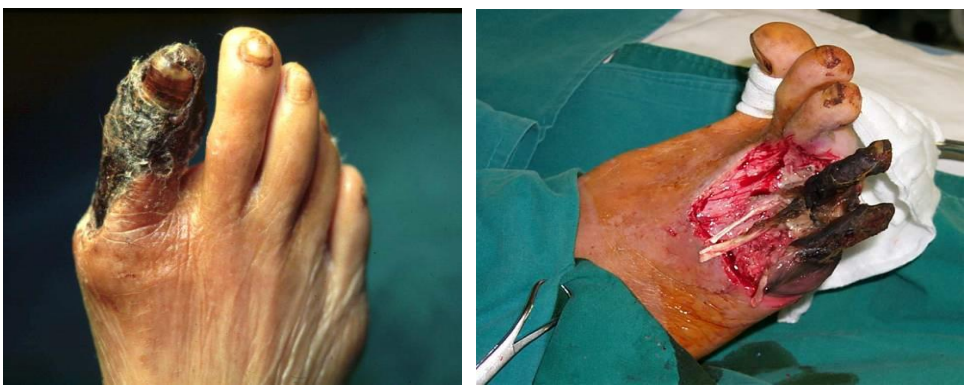


Figure (18)foot ulces and gangrene.

Gangrene is usually caused by a minor local trauma, local pressure (fitting shoes), or use of local heat. Gangrenous tissue can shrink and form a scar leading to mummification and spontaneous amputation. However, necrotic tissue may also be infected with spreading of tissue loss.

(Schaper et al. , 2003)

Diagnostic modalities

COLOR DUPLEX IMAGING (CDI)

This technique combines brightness mode (B-mode) ultrasound with Pulsed Doppler spectral waveform analysis and color flow imaging. It facilitates the noninvasive assessment of the vessel location, its wall, and a detailed analysis of blood flow characteristics at various points within the lumen at contiguous multiple levels.

Spectral waveform analysis can display details of the waveform patterns at selected points within the lumen. Stenoses cause an increased velocity of blood locally. Turbulent post-stenotic flow causes a widening of the waveform outline due to the wider range of velocities, termed “spectral broadening.”

Color flow imaging displays the blood flow in the entire lumen within the section being studied. It allows geometric measurement of a stenosis by comparing the relative thickness

of the wall with the section with visualized flow. Homogenous color depicts normal laminar blood flow, bright and granular color patterns indicate turbulent flow, termed “aliasing.” This type of picture typically occurs where stenotic lesions cause a less than 50% reduction in the internal diameter,equivalent to a 75% reduction in cross-sectional area of the lumen .

(Hamik and Creager , 2008)

Color duplex imaging (CDI) can also prevent patients with less severe or inoperable disease being unnecessarily exposed to invasive procedures .Higher frequency probes have also demonstrated accurate visualization of distal vessels.

Medial sclerosis, frequently seen in the infrageniculate arteries in diabetes, typically has a uniformly high signal on B-mode ultrasound, but generally permits flow analysis. Dampened waveforms with reduced peak velocity indicate the presence of significant stenotic disease proximal to the point of analysis.

Further, there is the potential to fail to localize significant arterial disease proximally, particularly in obese individuals and to miss distal disease in small vessels so preventing accurate anatomical mapping. **(Hamik and Creager , 2008)**

Transcutaneous Oxygen Tension (TcPO2)

TcPO2 is a well-established indicator of arterial oxygen tension used widely in neonatal medicine. It is quantifiable and accurately reflects cutaneous perfusion. Numerous studies of noninvasive lower limb perfusion have identified that a TcPO2 of less than 30 mmHg is consistent with poor healing in both lower limb amputation and ulcer healing .

Values in patients with diabetes, particularly with peripheral neuropathy (and no macrovascular disease), are often lower than that in nondiabetic controls because of a decreased cutaneous microcirculatory response to local heating . TcPO2 has been widely used in diabetes in an effort to predict healing of amputation sites and foot ulceration in patients with distal PAD, frequently not amenable to intervention .

(Williams et al. , 2006)

ANGIOGRAPHY

This is the “definitive” method for anatomical evaluation of lower limb arterial disease when revascularization is planned. Conventional angiography shows the outline of the lumen, and therefore the outline of the artery wall, and where there is narrowing, and to some extent the severity of the arterial disease process at each location .

Occlusions and length of occlusions are seen, as well as collaterals and the quality of collateral blood flow. Importantly the quality of the profunda femoris is demonstrated, and the presence and quality of the popliteal artery. Angiography may point to either open or endovascular repair.

(Hamik and Creager , 2008)

Arteriography provides a view of the circulatory tree that is easily interpreted by the surgeon familiar with this format . In addition to providing valuable anatomic information, pressure measurements across arterial stenoses can be used to gauge the homodynamic severity of a lesion, and intervention can be undertaken via concurrent balloon angioplasty and/or stenting.

The disadvantages of arteriography are well documented and include procedure related complications, patient discomfort, and high costs. Periprocedural complications can include hematoma, pseudoaneurysm or arteriovenous fistula formation, embolization, and dissection, to name a few.

In addition, patients may experience temporary or permanent renal failure caused by the contrast infusion. Arteriography is uncomfortable for patients and requires them to undergo preprocedural bloodwork and to spend the better part of a day in the interventional suit. **(Aspelin et al. , 2003)**

Lesion anatomy can be assessed using digital subtraction angiography and according to this it was classified by **The modified TASC classification** for tibioperoneal occlusive disease as follows:

- TASC A: a single stenosis 1 cm long.
- TASC B: multiple focal (1 cm) stenoses of the tibial or peroneal arteries,including up to two focal stenoses at the tibial trifurcation, or short tibial or peroneal stenoses in conjunction with femoropopliteal disease.
- TASC C: Longer stenoses of 1 to 4 cm and occlusions of 1 to 2 cm as well as extensive stenoses at the tibial trifurcation.
- TASC D: occlusions 2 cm and diffusely diseased tibial vessels. **(Norgren et al. , 2007)**

Computed Tomography Angiography (CTA)

CT angiography is an alternative imaging study that is also undergoing considerable investigation as an alternative to contrast arteriography. Technologic improvements are allowing the peripheral vessels to be imaged in an improved fashion. CT angiography is dependent on the software and the technician performing the studies for optimal image acquisition and interpretation.

In addition, anatomic information regarding the location of stenosis may be obtained; however, the hemodynamic

significance of these lesions is difficult to quantify. CT angiography (CTA) can assess peripheral vascular anatomy and significant stenosis, and select candidates for further intervention. **(Hirsch et al. , 2006)**

The use of CT to image infrainguinal vascular disease has been increasing with the development of improved computer software and hardware for CT scanners. Computerized 3D reconstruction enables a large number of fine slices from one CT scan to be reproduced as high-quality 3D images of the contrast enhanced vessels. The fast scan time allows all the data to be collected during the first pass of an intravenous bolus of contrast through the arteries. **(Donelly et al. , 2000)**

This reduces the artifact caused by patient movement. This technology enables CT angiography, and the resolution of the images of contrast enhanced vessels is adequate for evaluating occlusive disease. The latest advance in CTA is fast multislice CT (64 and 128 and 256 slice) which provides outstanding detail of the peripheral vessels. **(Fillinger and Whittaker , 2005)**

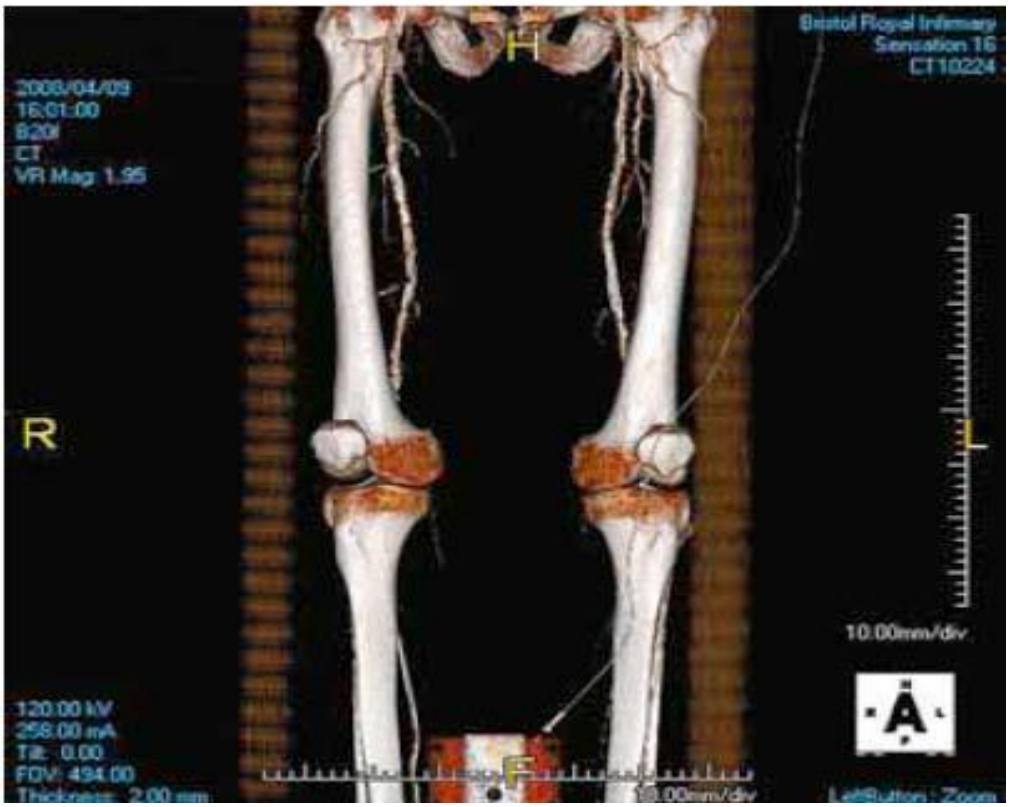


Figure 19 : Contrast computed tomography angiography demonstrating diffuse, nonocclusive, stenotic right superficial femoral artery disease. **(Quoted from Hamik and Creager , 2008)**

Magnetic Resonance Angiography (MRA)

Magnetic resonance angiography (MRA) produces (relatively) noninvasive,three-dimensional, cross-sectional images. It is very effective in the evaluation of stenoses, where it has a sensitivity of 99.5% and specificity of 98.8% when compared with DSA (digital subtraction angiography). It is cost effective, and superior to DSA in that it will demonstrate the vessel from any rotational angle and also in seeing distal vessels in some patients. **(Insko et al. ,2006)**

MRA can also be used to evaluate results after treatment, to monitor grafts, and to look for post-operative complications

such as pseudoaneurysms. It enables the selection of patients for endovascular intervention or surgery . One limitation is that it tends to overestimate stenoses, and may be inaccurate in the presence of stents.

There are a number of contraindications to MRI, for example the presence of a pacemaker, or cerebral artery clip. MRI utilizes a large external magnetic field, with gradients applied across it and an oscillating magnetic field known as the radiofrequency field or RF field. This combination allows the operator to produce signals from inside the patient which are used to generate the MR images.

(Hirsch et al. , 2006)

MR images depend on the characteristics of the object being imaged.T2 weighted images display simple fluids like urine, bile, or CSF as bright and other tissues as darker. T1 weighted images display flow effects, MRI contrast agents, fat and methemoglobin as bright, and are therefore used in MRA and MRV. Contrast-enhanced MRI produces superior MRA images.

The contrast (gadolinium) shortens the T1 value of the protons in the local vicinity, making them more conspicuous on T1 weighted sequences. Gadolinium still has some nephrotoxic effects, but is less nephrotoxic than iodinated contrasts, and

much less is required in MR than either CT or conventional angiography. Similar to duplex ultrasonography, the technique is operator dependent .

Another potential disadvantage of magnetic resonance imaging is that only anatomic information is provided . There is no physiologic means to grade the degree of stenosis or the significance of a lesion, once discovered. In addition, many patients may not be able to tolerate the claustrophobic conditions and the time required for MRA scanning. However, open design MRA are available .

(Insko et al. , 2006)

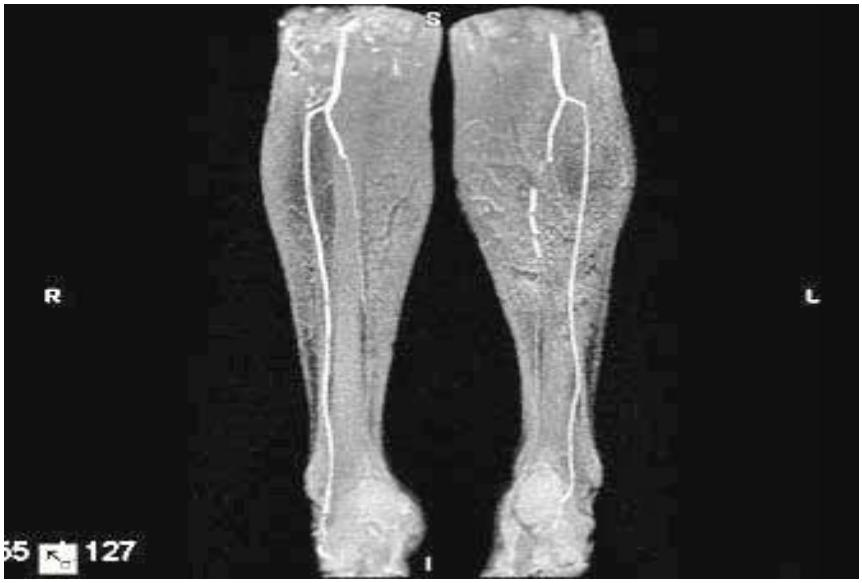


Figure 20 :Lower extremity MRA showing severe stenoses in right posterior tibial artery and several stenoses in left posterior tibial artery.

(Quoted from Hamik and Creager , 2008)

Treatment

Treatment

The primary goals of the treatment of CLI are to relieve ischemic pain, heal ischemic ulcers, prevent limb loss, improve patient function and quality of life, and prolong survival. The main outcome would be amputation-free survival, as shown in diagram 1. **(Norgren et al., 2007)**

Because atherosclerosis is a systemic disease, the initial treatment of lower extremity PAD should include risk factor modification in an effort to limit progression of the atherosclerotic process in the affected limb and in other territories. **(York and Taylor, 2010)**

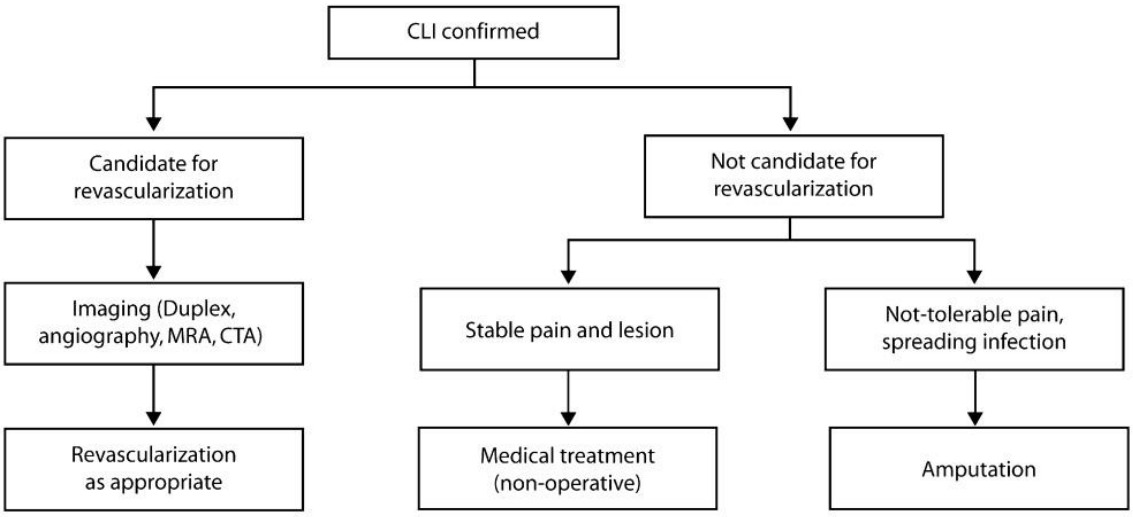


figure (21): shows treatment of CLI patients. ***(Quoted from Norgren et al., 2007)*** *CLI; critical limb ischaemia, MRA; magnetic resonance angiography, CTA; computed tomographic angiography*

Medical treatment of PAD

Three fundamental principles are involved in the treatment of symptomatic PAD.

First, the risk factors must be identified and aggressively treated and/or modified. The 2 most important risk factors for PAD are cigarette smoking and diabetes.

Secondly, initiate a walking exercise program. more than 28 prospective randomized clinical trials were done to prove the efficacy of walking exercise to treat claudication. Every trial has demonstrated improvements in walking distance from 180-340%. Supervised walking programs usually produce better results than unsupervised exercise. Walking exercise improves symptoms of claudication because the muscle enzymes involved in oxygen extraction and utilization become more efficient over time. ***(Weitz, 2000; Gardner, 1995)***.

Finally, Food and Drug Administration (FDA)-approved pharmacologic agents may improve the symptoms of claudication caused by lower extremity arterial occlusive disease.

1) Risk factors modification:

- **Smoking cessation** **(Francesco et al. ,2006)**

Cigarette smoking is a major modifiable risk factor for cardiovascular disease, affecting the coronary, cerebrovascular, and peripheral arterial territories. Cigarette smoking is considered the single most important risk factor for PAD, the risk being 16-fold higher for claudication in patients with PAD over 45 years who smoke.

The 5-year mortality rate among PAD smokers is > 60%. Carbon monoxidemia probably predisposes to arterial wall injury by producing increased plasma flux into the arterial wall and entry of LDL and other proteins. Cigarette smoking causes increased platelet reactivity, promotes peripheral vasoconstriction, and is associated with reduced HDL levels.

The risk of PAD in smokers is three- to fourfold that of nonsmokers. Smoking cessation improves outcomes including walking times , CLI , patency of grafts, and amputation . Unfortunately, the efficacy of counseling is low. Organized cessation programs, nicotine replacement therapy, and buproprion increase abstinence rates and reduce recidivism .

- **Treatment of dyslipidemia**

(Francesco et al. ,2006)

Drugs currently available include cholestyramine and cholestepol,which are bile acid sequestrants, nicotinic acid (a B-complex vitamin), Gemfibrozil, a fibric acid derivative that acts in the liver to elevate plasma HDL and lower triglycerides and LDL, and the statin drugs.

The current recommendations of target values for LDL cholesterol are less than 100 mg/dl or 2.6 mmol/l and for serum tryglicerides less than 150 mg/dl or 1.7 mmol/l. The treatment should be started with statins and niacin should be added for increasing HDL cholesterol concentrations and lowering serum triglyceride concentrations, without alterations in glucose metabolism.

The drug probucol and the natural vitamins E and C are antioxidants which may impact the deleterious effects of oxidized LDL. The role of antioxidants and correlation with plaque dynamics has emerged as an important new consideration, as these agents might be used as drugs**.**

- **Treatment of diabetes mellitus**

Tight control of blood glucose levels in Type 1 and Type 2 diabetics has not been shown to have a significant effect on large vessel end points, even when improvement in microvascular events (i.e., retinopathy, nephropathy) is demonstrated .

The American Diabetes Association has published guidelines for patients with PAD . Prevention of microvascular complications is improved by meeting a goal hemoglobin A1c of <7%. **(Dormandy et al. , 2005)**

- **Treatment of other metabolic risk factors**

Hyperhomocysteinemia is recognized as an independent risk factor for PAD and cardiovascular death which leads to endothelial dysfunction and proliferation of vascular smooth-muscle cells. The causes of hyperhomocysteinemia can be treated by supplementing the diet with vitamin B12 or folate, both of which reduce serum homocysteine concentration, although there is no clinical evidence of beneficial influence in patients with PAD. **Collins and Mcmullan , 2008)**

- **Treatment of hypertension**

Intensive blood pressure control significantly reduces the relative risk of cardiovascular events in these patients . Angiotensin-converting enzyme (ACE) inhibitors should be considered first-line agents even normotensive patients with PAD may benefit from ACE-inhibitor therapy. Additionally, despite conventional teaching, β-blockers do not worsen intermittent claudication, and most patients do well on these agents .

Only in the small subset of patients with CLI does particular caution need to be exercised with antihypertensive therapy, as reduction in perfusion pressure may exacerbate the ischemia. Nonetheless, these patients do require long-term antihypertensive therapy. **(Mehler et al. , 2003)**

2) Exercise therapy:

The benefits of exercise are due to a combination of increased oxidative capacity of skeletal muscles and better walking mechanics and, possibly, collateral blood vessel development, enhancement of nitric oxide-mediated vasodilation, and improved hemorrheology .

All patients with lower extremity PAD should be enrolled in supervised exercise programs and undergo comprehensive cardiovascular risk assessment with a treadmill exercise test prior to initiation of the program. The programs should utilize a treadmill or track in sessions of 45 to 60 minutes at least three times a week for a minimum of 12 weeks .

During the exercise session, patients should walk until moderate to severe symptoms of claudication develop, rest until they resolve, and then continue with the exercise. This cycle should be repeated for the duration of 45- to 60-minute training period. **(Degischer et al. , 2002)**

3. pharmacological drugs:

A.Antiplatelet drug therapy

- ***Aspirin***

Aspirin therapy significantly improved peripheral circulation. In patients with PAD, submitted to peripheral angioplasty or bypass surgery using saphenous vein or prosthetic graft and followed for about 19 months showed a 43% reduction in the rate of vascular graft occlusion. Aspirin was administered alone or in combination with dipyridamole, sulfinpyrazone or ticlopidine. **(Collins and Mcmullan, 2008)**

Although aspirin is the most widely used and cheapest antiplatelet drug, approximately 10–18% of the population

appear to be unable to take it because of gastrointestinal discomfort or risk of gastrointestinal hemorrhage.

(Collins and Mcmullan , 2008)

Aspirin is equally effective in men and women. In men, aspirin mainly reduces the risk for myocardial infarction, whereas in women aspirin lowers the risk for stroke**.**

(Berger et al.,2006)

Aspirin, typically in daily doses of 75 to 325 mg, is indicated in individuals with CLI, prior lower extremity revascularization (endovascular or surgical), or prior amputation for lower extremity ischemia.

(Anderson et al., 2013)

- ***Clopidogrel***

Clopidogrel belongs to the same group of thienopyridine drugs. Its benefits in the therapy of patients with PAD has the support of data derived from the **Clopidogrel Versus Aspirin in Patients at risk of Ischemic Events (CAPRIE) trial.**

Treatment with clopidogrel was associated with an 8.7% reduction of fatal or non-fatal ischemic stroke, fatal or non-fatal myocardial infarction, or death from other vascular causes.

These results convinced the FDA to approve clopidogrel in the secondary prevention of atherosclerotic disease.

Clopidogrel and aspirin were well tolerated, though there was an estimated risk of four cases per million patients of thrombotic thrombocytopenic purpura. **(Aramow, 2004)**

The thienopyridine derivative, clopidogrel, interferes with platelet function by blocking the antiplatelet drug receptor. One trial found that clopidogrel had greater efficacy than aspirin in preventing cardiovascular events in patients with lower extremity PAD.

Dual antiplatelet therapy with clopidogrel and aspirin, compared to aspirin alone, did not improve outcomes in a large trial of patients with documented coronary artery disease, PAD, and cerbrovascular disease and those with multiple risk factors or asymptomatic atherosclerosis.

Recommendations are that all patients with lower extremity PAD should receive antiplatelet therapy with either aspirin at 75 to 325 mg/day or clopidogrel at75 mg/day.

(Hirsch et al. , 2006)

Recent concerns about late in-stent thrombosis with drug-eluting stents have led some experts to recommend long-term use of clopidogrel plus aspirin for this indication**.**

(Eisenstein et al.,2007)

2011 ACCF/ AHA guidelines recommended the combination of aspirin and clopidogrel to reduce the risk of cardiovascular events in patients with CLI, prior lower extremity revascularization (endovascular or surgical treatment), or prior amputation. **(Anderson et al., 2013)**

Prasugrel is irreversible thienopyridine with adenosine diphosphate receptors antagonism action on the platlets. It has a faster onset of action time and greater potency versus clopidogrel. The combination of prasugrel plus aspirin significantly reduced the risk of the composite end point of death from CV causes, nonfatal Myocardial Infarction, or nonfatal stroke versus the combination of clopidogrel plus aspirin.

Treatment with prasugrel demonstrated a net clinical benefit (the combination of effects on ischemic events and bleeding) versus clopidogrel in patients with diabetes, and patients receiving stent.

Ticagrelor is a non thienopyridine, direct acting, and second generation selective inhibitor of the ADP receptor with rapid onset of action (2 hours to peak platelet inhibition). Importantly, ticagrelor binding to the ADP receptor is reversible, with partial recovery of platelet aggregation within 12 hours after discontinuation of treatment. **(White, 2011)**

B. Vasodilators

- ***Prostaglandins***

Prostaglandins with antiplatelet and vasodilatory effects, such as prostaglandin E1 (PGE1) and prostaglandin I2 (PGI2), have been administered IV or intra-arterially to patients with advanced chronic arterial insufficiency in hopes of relieving rest pain and healing ischemic ulcers.

Selective intra-arterial PGI2 was found to relieve rest pain and promote healing of ulcers . Prostanoids, including the stable prostacyclin analogue iloprost, have received widespread attention in Europe for the pharmacologic treatment of CLI.

They induce vasodilation, as well as inhibiting platelet aggregation. Prostanoids must be given intravenously or intra-arterially. Data suggest that prostanoids need to be given for at least 72 h; short-term therapy has not been effective.

(White and Hollier, 2005)

Prostanoids prevent platelet and leukocyte activation and protect the vascular endothelium, which could play a role in the management of CLI.These drugs are administered parenterally over several weeks. Side effects include flushing, headache, and hypotension of a transient nature.

In clinical practice, iloprost seems to be of benefit to about 40% of patients in whom revascularization is not possible.

(Brass et al. , 2006)

A review article on iloprost reported by the United Kingdom Severe Limb Ischaemia Study found an amputation rate of 32% for iloprost recipients and 47% for a placebo group at 6 months.

(White and Hollier, 2005)

An oral preparation of prostaglandin I_2 (beraprost) was studied in a European trial in which 424 patients with intermittent claudication were randomized to receive 40 µg three times a day or placebo for 6 months. There was a significant increase in pain-free walking distance at 6 months in the beraprost group—an average increase of 36 m—compared with the placebo group (81% versus 52.5% increase; $P = .001$).

The treatment group also realized a significant increase in maximal walking distance compared with the placebo group,

with a mean increase of 70 m (60% versus 35% increase; *P* = .004)**.** **(lievre et al.,2000)**

- ***Cilostazol***

Cilostazol is a phosphodiesterase III inhibitor with vasodilator, metabolic and antiplatelet activity. Cilostazol (Pletal) gained FDA approval in 1999 for the treatment of PAD.

Oral administration of this phosphodiesterase III inhibitor increases cyclic adenosine monophosphate (cAMP) and results in a variety of physiologic effects, including the inhibition of smooth muscle cell contraction and platelet aggregation. Cilostazol is also thought to decrease smooth muscle cell proliferation, a process that has been implicated in coronary artery restenosis following percutaneous transluminal angioplasty. **(tsuchikane et al.,1999)**

The benefits of cilostazol in the treatment of PAD were compared with those of pentoxifylline in a randomized controlled trial performed by Dawson and associates. They found that cilostazol therapy significantly increased maximal walking istance by 107 m (54% increase), compared with a 64-m improvement in the pentoxifylline group (30% increase).

(Dawson et al.,2000)

Since the drug is in the phosphodiesterase III inhibitor class of drugs, it should not be given to patients with any evidence of congestive heart failure because of a theoretical concern for increased risk of mortality. This drug has the best overall evidence for treatment benefit in patients with claudications.

(Regensteiner et al. , 2002)

C.pain control

The hallmark of CLI is ischemic rest pain and painful ulceration.Initial attempts at pain relief should include the use of acetaminophen/paracetamol or nonsteroidal anti-inflammatory medications although the latter are rarely effective and narcotic medications are frequently required. Caution should be used in the latter in patients with hypertension, or renal insufficiency.

Control of pain is usually more effective if analgesia is given regularly rather than on demand. Placing the affected limb in the dependent position provides partial relief of ischemic pain in some patients. Therefore, tilting the bed downward may be a helpful measure in addition to analgesia. Patients with CLI are often depressed and pain control can be improved by use of antidepressant medications.

(Norgren et al. , 2007)

Glycoprotein IIB/IIIA (GP-IIb/IIIa) inhibitors

GP-IIb/IIIa is the most abundant receptor on platlets and it is inactive on resting platelets. When platelets are activated, inside-outside signal transduction pathways trigger conformational activation of the receptor. Once activated, GP-IIb/IIIa binds adhesive molecules such as fibrinogen and von Willebrand Factor. Once bound, fibrinogen or vWF (or both) bridge adjacent platelets together to induce platelet aggregation. **(Weitz, 2010)**

Abciximab, eptifibatide, and tirofiban are GP-IIb/IIIa receptor inhibitors; Abciximab and eptifibatide are used in patients undergoing percutaneous coronary interventions, particularly those with acute myocardial infarction. Tirofiban is used in high-risk patients with unstable angina. Eptifibatide can also be used for this indication. Doses of eptifibatide and tirofiban must be reduced in patients with renal insufficiency.

(Weitz, 2010)

D. Anticoagulants

Unfractionated heparin is frequently used as prophylaxis and as adjuvant treatment to vascular surgical procedures, but has not been tried for symptoms of CLI. Two studies have looked at low

molecular weight heparin (LMWH) in CLI patients with ulcers. These were negative trials. Vitamin K antagonists have not been tried for the treatment of symptoms of CLI. Defibrinating agents have not been shown to improve healing of ischemic ulcers or to reduce the number of amputations.

(Norgren et al. , 2007)

Surgical and Endovascular treatment of PAD

BASIL study is an important multicenter and randomised controlled trial study that helped to clarify the role endovascular and bypass surgery, and difference of the outcomes for revascularization of critical limbs ischaemia whom treated with angioplasty first versus limbs whom treated with bypass surgery first. BASIL group found that in 6 months follow up, the two methods of treatment had almost equivalent results with regard to amputation-free survival. **(Adam et al., 2005)**

In 6 months follow up, BASIL group found that, a surgery first strategy was associated with a significantly higher rate of morbidity, and significantly greater length of hospital stay than that of an angioplasty first strategy.

They also found that reintervention rate in angioplasty was higher than in surgery. Also after 2 years follow up, surgery was associated with a lower amputation rate, and death rate than endovascular. **(Adam et al., 2005)**

Then, TASC 2 recommended that in a situation where endovascular revascularization and bypass surgery of peripheral

arterial disease give equivalent short term improvement, endovascular techniques should be used .

(Norgren et al., 2007)

In 2010, Bradbury and his associates had continued the follow up of BASIL study patients for 7 years. They found that balloon angioplasty was associated with a significantly higher early failure rate than bypass surgery. Most balloon angioplasty patients ultimately required secondary bypass surgery.

(Bradbury et al., 2010)

Bypass surgery outcomes after failed balloon angioplasty are significantly worse than for bypass surgery first and the bypass surgery with vein conduit offers the best long term amputation free survival and overall survival. They also found that balloon angioplasty appears superior to prosthetic conduit bypass surgery. **(Bradbury et al., 2010)**

In 2011 the American collegue of cardiology foundation (ACCF) / the American heart association (AHA) recommended that for patients with CLI and an estimated life expectancy of 2 years or less or in patients in whom an autogenous vein conduit is not available, balloon angioplasty is reasonable treatment option to perform when possible as initial procedure to improve distal blood flow. **(Rooke et al., 2011)**

In the same year 2011, Schmidt et al have published the results of his first experience of drug eluting balloons in infrapopliteal angioplasty. They found that DEBs in infrapopliteal angioplasty demonstrated a marked, more than 60% reduction in the restenosis rate at 3 months in comparison with bare balloon angioplasty. In addition, if restenosis occurred, it was associated with a favorable, focal pattern. After one year follow up, Limb salvage was 95.6%. **(Schmidt et al., 2011)**

From December 2002 to septemper 2010, 433 patients underwent infrainguinal revascularization for critical limb ischaemia of 514 limbs. 295 patients were treated endovascularly with 363 limbs and 138 patients with 151 limbs were treated surgically. Regarding limb salvage rate, there is no difference between endovascular and bypass revascularization in treatment of crtical limb ischaemia. In the endovascular vs open group, 5-year limb salavage was 78% ± 3% vs 78% ± 4%(P =0.992). **(Dosluoglu et al., 2012)**

Schamp et al concluded from their study that angioplasty and surgery are clearly complementary. In spite of Patency rates of infrapopliteal bypass surgery are still superior compared with angioplasty, but described limb salvage rates are comparable.

(Schamp et al., 2012)

Contraindications of revascularization procedure are: unreconstructable infragenicular vessels (no outflow vessel), fixed flexion contractures of the knee, or acute septicemia related to wet gangrene of the foot requiring emergent amputation**.** **(York and Taylor, 2010)**

Some CLI patients with severe comorbidities or a very limited chance of successful revascularization, a primary amputation may be the most appropriate treatment.

(Norgren et al., 2007)

Equipments of angioplasty

By definition, all endovascular procedures require the surgeon to gain access to the lumen of the arterial or venous system in order to proceed.Although this can be performed percutaneously or by direct surgical exposure of the access vessel, the overwhelming majority of endovascular procedures can and should be performed via the percutaneous route of vascular access. **(Ayerdi and Hodgson, 2005)**

Choosing an imaging system

Fluoroscopy is the modality used for digital subtraction angiography. Fluoroscopy functions via an image intensifier that

receives,concentrates, and brightens an X-ray image to produce an electronic image that can be displayed on a screen. The larger size of an image intensifier usually allows for better quality imaging.

A standard imaging suite image intensifier is 15 inch. in diameter, whereas a standard image intensifier on a portable C-arm is 12 inch. in diameter. Both of these systems allow control of the irradiation by the use of a foot pedal.

(Mohiuddin et al., 2006)

Despite the significant technical improvements in the current model of C-arm systems, the image quality remains slightly inferior to that obtained from the angiosuite. This is due to several factors including higher focal spot size, fixed distance between the X-ray tube, and the power output of a C-arm image intensifier.

A common concern about the mobile C-arm unit is its propensity to overheat. When this happens, the unit must be shut down and allowed to cool, which can be severely limiting. In contrast to a mobile fluoroscopic unit, an angiosuite is typically more robust with less likelihood of overheating.

In addition, all the necessary imaging equipments,such as image intensifier, fluoroscopic table, and power injector are typically electronically integrated in an angiosuite. Consequently, activating the image intensifier dims the room lights, initiates the imaging sequence, and times the injector activation.

(Hodgson et al., 2003)

Both portable C-arm and an angiosuite imaging units have specialized functions that are commonly used during interventions.Magnified views are obtained when focusing on a limited area such as the aortic bifurcation for kissing stent deployment. Another feature is the road map technique. This allows for a representation of the arterial tree by contrast angiography on one digital screen with real-time fluoroscopy on another.

Fluoroscopic images can be adjusted in different oblique angles to enhance the accuracy of visualizing certain vascular anatomy, such as the internal iliac arteries or the aortic arch. The most commonly used fluoroscopic angle is anteroposterior (AP) projection. **(Mohiuddin et al,2006)**

Imaging table

The imaging table is an integral part of the endovascular suite.Although it is possible to perform an endovascular procedure in an operating room using a conventional operating

room table, there are many drawbacks including variability in the cushioning and underlying metals provides for a nonuniform path for the radiation.

For endovascular procedures, the primary requirement of the imaging table is that it must be radiolucent. In general, there are two types of radiolucent tables; fixed and movable.

(Mohiuddin et al., 2006)

Power injector

There are two methods for delivering contrast: hand injection with a syringe and electronically calibrated precise power injection. For most small vessel and selective angiography, hand injection is adequate. However, for optimal opacification of high-flow blood vessels like the aorta, the use of a power injector is mandatory.

Conversely, the power injector is also useful in small vessels when the contrast must be injected at a fixed slow rate. The power injector permits the operator to determine the rate of injection, total volume of injection, and pressure of the injection.

(Mohiuddin et al., 2006)

Equipments of vessel puncture

There are basically two types of entry needles to choose from: single- and double-wall puncture types: The single-wall puncture needle is most familiar to surgeons and the one most commonly used. It is a bevel tipped 16- or 18-gauge hollow needle that accommodates a 0.035-inch guide wire.

(Ayerdi and Hodgson, 2005)

The second major category of needles are the double-wall puncture needles (Fig. 22), which are two component systems that combine a blunttipped hollow needle with a bevel-tipped stylet that projects slightly out the end of the needle.

(Kluge et al., 2003)

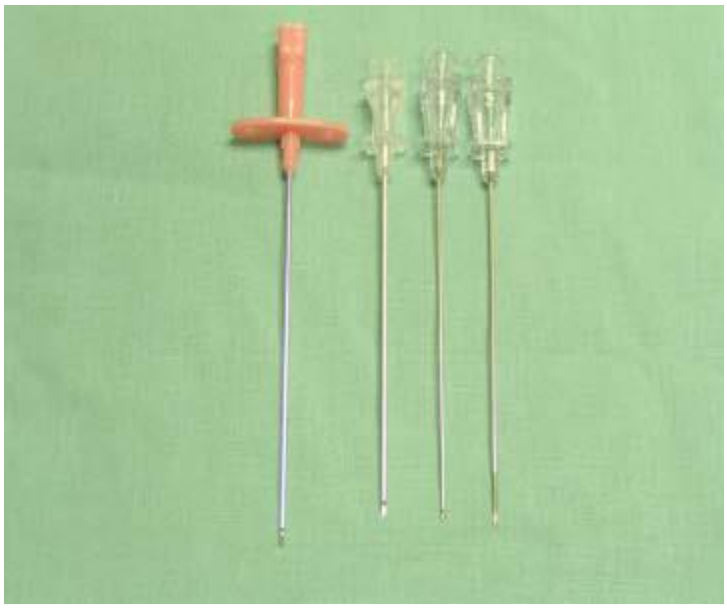


Figure (22): A double-wall puncture needle (left) and three single-wall needles (right) (Quoted from **Ayerdi and Hodgson, 2005**).

Sheaths

Use of a sheath is absolutely mandatory for interventional procedures to prevent device-related vessel wall injury. Sheaths are essentially access ports to the vascular system placed at the time when initial vascular access is achieved and removed after completion of the diagnostic study or intervention.

Subsequent exchanges of guide wires, diagnostic catheters, and interventional catheters or devices all are performed through the lumen of the sheath, which functions to maintain access to the vascular system while minimizing trauma to the vessel wall as well as extravasation of blood from the puncture site during exchanges.

Back-bleeding from the sheath itself is prevented by a hemostatic valve located in its hub, which also maintains hemostasis when catheters or guide wires are in place by sealing around these devices **(Hughes et al., 2000)**

Sheaths come in a variety of diameters and lengths, but the diameters most commonly used are in the 5- to 6-French range (1 French = 0.33 mm or 0.013 inch), because most diagnostic and balloon catheters are of this size.

(Ayerdi and Hodgson, 2005)

Sheaths are generally 10–11 cm in length. Longer (30–100 cm) sheaths are used for a variety of purposes. This includes straightening out the tortuous iliac vessels, improving torque control and facilitating guide catheter, stent, and stent graft advancement. **(Dougherty and Krajcer ,2008)**

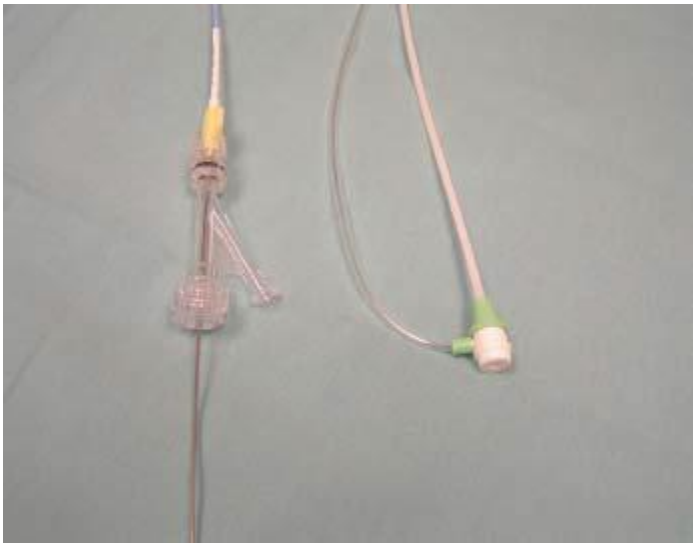


Figure (23): Y-adapter on a guiding catheter (left) and hemostatic valve of a sheath (right) (Quoted from **Ayerdi and Hodgson, 2005**).

Guiding Catheters

Guiding catheters are larger diameter catheters, usually pre shaped to one of the self-forming curves, through which balloon catheters or other interventional devices are passed.

One use of guiding catheters during endovascular interventions is to provide a mechanism to angiographically evaluate the results of the intervention without losing access to the treated area because it is generally advisable that a lesion undergoing

treatment remain traversed by a guide wire or catheter (referred to as maintaining lesion crossing) at all times until a successful interventional result has been demonstrated **(Bates, 2007)**

Angiographic catheters

Angiographic catheters are constructed of polyethylene, polyurethane, nylon, Teflon, or a combination of these materials. Catheters made of polyethylene have a low coefficient of friction, can be torqued and have a good pre shaped memory. Polyurethane catheters are softer and pliable, but have a higher coefficient of friction.

(Dougherty and Krajcer ,2008)

Catheters vary in length and diameter. Outer diameter is designated by French size. Angiographic catheters are available in multiple shapes and sizes and can be divided into two basic categories: selective and non-selective.

Non-selective catheters are usually designed with multiple side-holes, like the “pigtail” or “Omniflush” (AngioDynamics Inc., Queensbury, NY) and are used for angiography of large vessels, such as the aorta or vena cava .

(Dougherty and Krajcer , 2008)

Procedure

- ## Vascular access

1. **Common femoral approach**

Usually performed using either ipsilateral antegrade common femoral artery (CFA) access or contralateral retrograde CFA access. Ipsilateral antegrade technique is more preferable than contralateral one because ipsilateral technique has several advantages; including providing superior support in treating complex occlusive disease and facility in treating distal tibial disease. **(Biondi-Zoccai et al., 2006)**

In spite of ipsilateral CFA access is associated with increased risk of bleeding at the access site (particularly in obese patients), the technical advantages offered by antegrade access outweigh the risk of bleeding. But if the patient had severe calcification at the puncture site, the contralateral approach should be chosen primarily. **(Biondi-Zoccai et al., 2006)**

2. **Retrograde ipsilateral approach**

Ipsilateral Retrograde recanalization technique of tibial occlusions had gained acceptance in case of the failure of antegrade approach to the lesion. The distal posterior tibial and dorsalis pedis vessels are the most commonly access vessels by

this technique because of their anatomic location and ease of access. **(Rogers et al., 2010)**

This access can be difficult even when performed under duplex-scanning and may result in vessel damage. This risk is even more important when the target artery is the single remaining infragenicular artery and the site of puncture is affected by a diffuse plaque burden. **(Airoldi et al., 2010)**

This access requires sufficient caliber of the anterior or posterior tibial artery below the ankle. Furthermore, this kind of intervention should only be tried by an experienced operator; since potential complications may damage the single patent run-off vessel and worsen surgical. **(Minar and Graziani, 2007)**

Use of fine needles is useful in retrograde ipsilateral tibial approach; 21 gauge needles are typically packaged with a short, 0.018 or 0.014-inch GuideWires and a 4 French (Fr) introducer with a coaxial dilator, as shown in figure24.

(Hodgson and Hood, 2010)

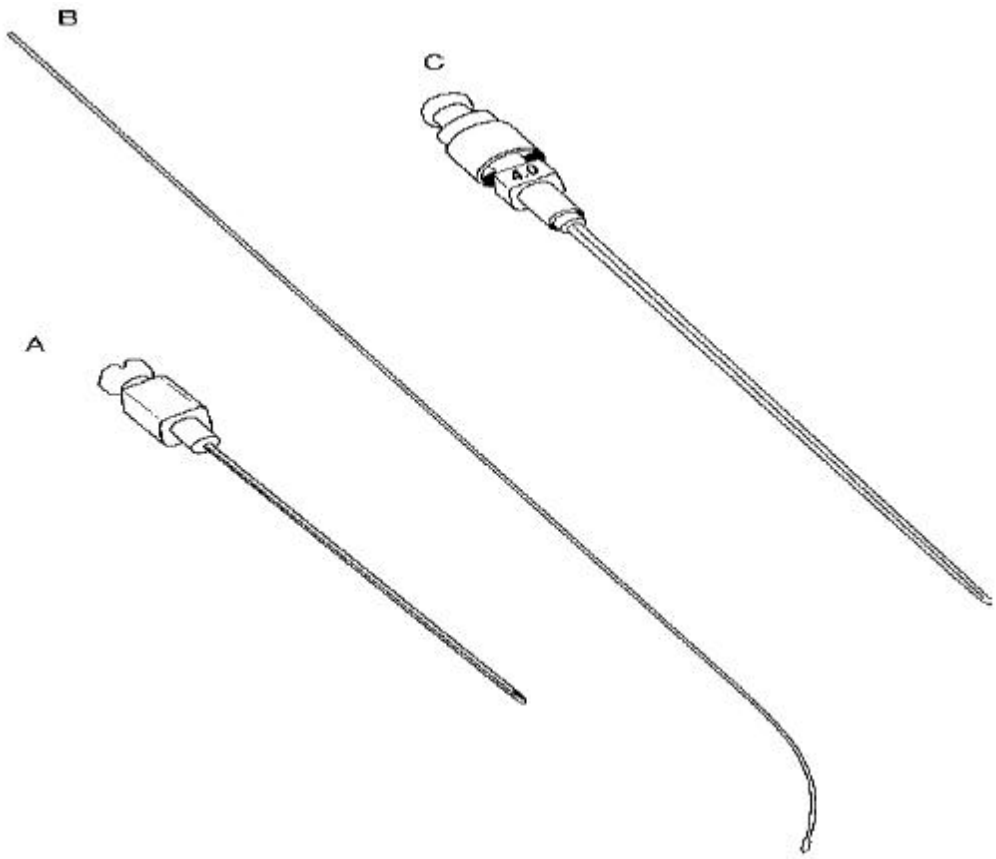


Figure (24): shows micropuncture set (Cook, Inc. Bloomington, Ind.) includes: A, 21- gauge needle, B, 0.018-in. guidewire, and C, a 4 Fr sheath.

Once the stenosis is crossed, the wire is snared and externalized. Then, catheter is advanced from the antegrade approach, and then the wire is removed and reinserted from the antegrade approach. **(Golzar et al., 2007)**

Selection of the vessel to be treated

Several studies assumed that the revascularization of the direct feeding vessel of the diseased angiosome of the foot would have implications in outcomes of revascularization. Kabra et al had conducted study on 64 CLI patients harboring non healing

ulcers of the feet. They found a significant healing of the ulcers when direct revascularization is done through 6 months follow up. **(Kabra et al., 2013)**

Soderstrom et al conducted a study on the difference of healing foot ulcers in diabetics after direct revascularization and indirect revascularization after infrapopliteal balloon angioplasty. They found that Foot ulcers treated with angiosome targeted vessel angioplasty healed better.

(Söderström et al., 2013)

As a rule of thumb, the length of the stenosis or occlusion is inversely proportional to the durability of results. Dilating an eccentric plaque may lead to differential distribution of lateral wall stress, resulting in subplaque hemorrhage and significant dissection. **(Hirsch et al., 2006)**

Peregrin et al. investigated the clinical and morphologic factors that might influence the clinical outcome of long-term follow-up in 1,445 PTA procedures. Peregrin demonstrated that the most important factor affecting the limb salvage rate was the number of patent runoff arteries after PTA, so PTA should be performed to open up as many arteries as possible, even in TASC D lesions to improve outcomes. **(Peregrin et al., 2010)**

Crossing the lesion

1. Transluminal angioplasty

A basic principle is to pass the wire through the lesion via the true lumen. So, one must be careful when dealing with preocclusive, highly stenotic (>90%) lesions. In this situation, magnified angiographic views, with correct projection of the image intensifier, are needed for precise imaging. The use of a 0.014-inch guide wire and an appropriately shaped guide wire tip is often helpful for crossing severely stenotic lesions.

(Sadek and Faries, 2010)

Conversion of a stenotic lesion into an occlusive lesion, will change the lesion to be more complex and difficult to handle, and will elongate the treatment area. For example, this may convert a Trans-Atlantic Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC) type A lesion into a TASC type C or D lesion, with a compromised long-term patency. **(Sadek and Faries, 2010)**

A lower profile catheter enables crossing of tighter lesions and more distal infrapopliteal arteries including pedal arteries. Hydrophilic coatings on the balloon catheter allow better

pushability and trackability through the sheath, access vessels, and lesions of interest. **(White et al., 2010)**

2. Subintimal Angioplasty

In 1989, Bolia and associates had described the first Subintimal angioplasty trial for the treatment of occluded femoropopliteal arteries.

Anatomically favorable lesions are those with a suitable length of relatively normal artery both proximal and distal to the occluded segment, which permits the creation of the subintimal dissection plane and reentry into the native lumen without potentially compromising major branch vessels during the procedure. **(Bolia et al., 1989)**

An angled hydrophilic guide wire and a balloon catheter (usually with a 3-mm-diameter, 2-cm-long balloon on a 120-cm-long 5-French shaft) are used to create a subintimal dissection plane above the level of the occlusion and to dilate the lesion.

The wire is then advanced, and naturally a loop is performed at the tip of the hydrophilic guide wire. The loop length is kept 2–3 cm, so that only the soft part of the guidewire makes the leading edge of the loop. This decreases the likelihood of perforation in these small and delicate vessels. The loop and catheter are then advanced through the subintimal plane until the occlusion is passed. **(Markose and Bolia, 2008)**

The subintimal dissection plane has a characteristic resistance when entered, traversed, and exited. A loss of resistance is often encountered as the wire reenters the true lumen of the native artery distal to the occlusion. Recanalization is confirmed by advancing the catheter over the guide wire beyond the point of reentry and obtaining an angiogram. **(Sumi and Ohki, 2010)**

The technique does not prerequisite the use of stents, and these should be placed only in flow-limiting dissection or elastic recoil. Patency, adequacy of flow, and preservation of runoff are confirmed by completion angiography.

A rapid rate of flow through the recanalized segment and the abscence of a spiral dissection are believed to be a strong predictor of a successful subintimal angioplasty. If it is difficult to reenter the true lumen after creating the subintimal dissection, reentry devices can be used.

(Sumi and Ohki, 2010)

If there is difficulty in reenter intraluminal distally, The OutBack LTD reentry catheter (Cordis Corp., Bridgewater, NJ) can be helpful with 80 or 120 cm long. At the distal end of the catheter is a 22-gauge reentry cannula (needle). The device is passed over a 0.014-inch guide wire into the subintimal space adjacent to the desired reentry location. **(Sumi and Ohki, 2010)**

Orienting the catheter under fluoroscopy using the radiopaque markers at the end of the catheter shaft aligns the cannula toward the true lumen. The guide wire is then partially withdrawn before deploying the cannula. By deploying the cannula, the intimal flap is penetrated from the subintimal space. The partially withdrawn guide wire can then be advanced into the true lumen, as shown in figure 25. **(Sumi and Ohki, 2010)**

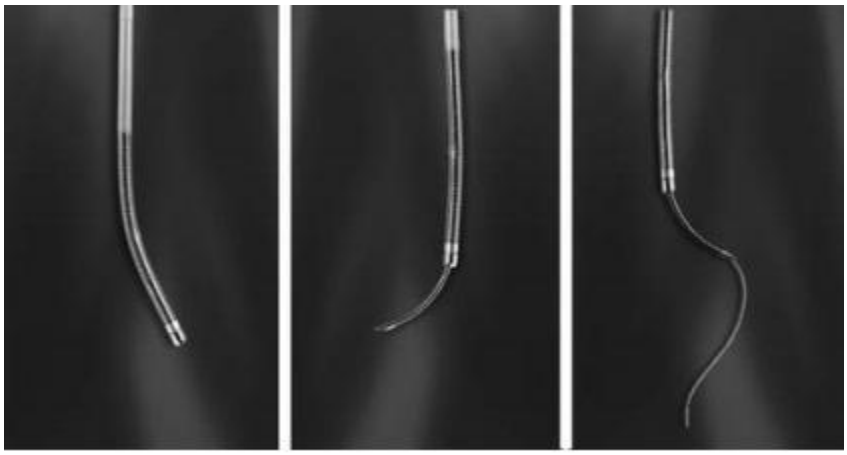


Figure (25): shows Outback catheter (quoted from Baweja and Heuser, 2008)

Treatment of the lesion

1. Balloon angioplasty (plain old balloon angioplasty)

A primary requisite for tibial intervention is the need for small diameter and extra-long balloons in length to avoid repeated inflations. Cordis Savvy long and Medtronic Amphirion deep are two examples of popular balloons that are especially well-designed for tibial angioplasty. **(Hadro, 2006)**

Figure (26): Amphirion DEEP (120 and 150 mm long balloons and 210 mm long conical balloons combined with 0.017" entry profile) enables treatment of diffuse lesions till the very distal foot arteries.

Most endovascular surgeons prefer noncompliant balloons especially in postdilatation of stents, which withstand high pressure inflation pressure. Non-compliant balloons are relatively inexpensive, and easy to handle, but unfortunately it is not resistant to mechanical irritation, such as from sharp edges of calcified plaques. **(Dougherty and Krajcer, 2008)**

Single-operator exchange (SOE) systems (monorail or rapid-exchange balloons) are modified Over The Wire balloons in which only the distal portion of the balloon catheter tracks coaxially over the guide wire; the remaining portion of the catheter shaft does not have a guide wire through-lumen.

(Sumi and Ohki, 2010)

Advantages of SOE include the procedure time can be shortened owing to faster balloon insertion and exchange and the only usage of standard-length guide wires. Disadvantages of SOE

balloons include less pushability, trackability, and the inability to reshape or exchange the guide wire without a transfer catheter. **(Sumi and Ohki, 2010)**

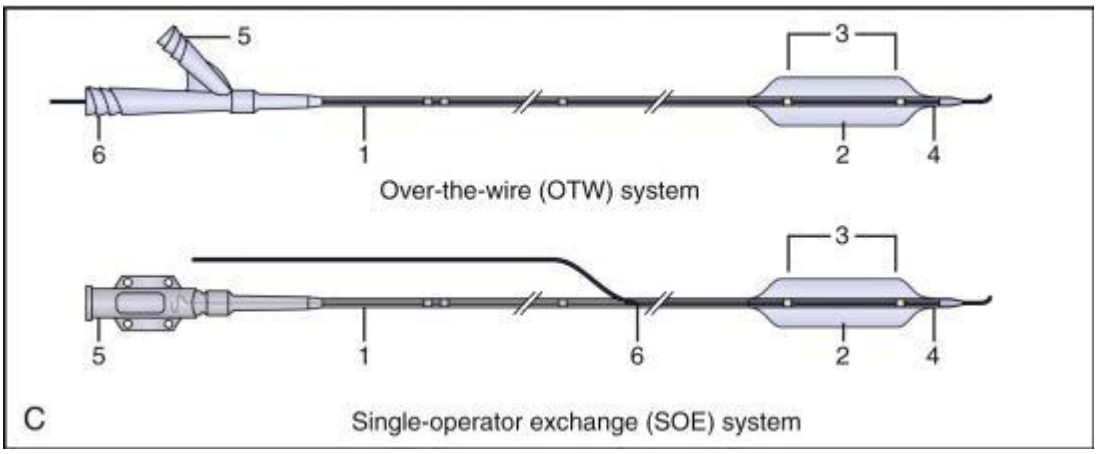


*Figure (27): shows on the top traditional over the wire catheter and in the buttom the single exchange system catheter. (Quoted from **sumi and ohki, 2010**)*

Acceptable long-term angioplasty results can be expected when short-segment concentric stenoses are dilated in the presence of good distal runoff and there is an immediate return of distal pulses. **(White et al., 2010)**

2. Drug eluting balloons (DEB)

Intimal hyperplasia is a normal proliferative response to disruption of the endothelium or mural injury after balloon dilatation of the arterial wall. Intimal hyperplasia is the predominant cause for restenosis after angioplasty and stenting. Local antiproliferative drugs are the most common methods to overcome intimal hyperplasia. **(Hong et al., 2003)**

Local antiproliferative drugs act through pharmacologic modulation of the local vasculature without imparting systemic tox-icity in response to injury. Drugs most commonly used are paclitaxel and sirolimus. **(Rochier and Sumpio, 2010)**

The In.Pact Amphirion was approved for peripheral artery application in Europe and therefore it was the only DEB used. Other DEBs may lead to differing results in the future.

(Schmidt et al., 2011)

Paclitaxel is an antineoplastic agent that is commonly used to treat breast and ovarian cancer. Paclitaxel impacts cell division in the mitosis phase of the cell cycle through centrosomal impairment, induction of abnormal spindles, and suppression of spindle microtubule dynamics. In clinical trials, paclitaxel has been shown to inhibit smooth muscle cell proliferation.

(Rochier and Sumpio, 2010)

Previously, Antiproliferative drugs were delivered by stents only, which have its complications. In 2008, Tepe et al published a randomized multicenter series of 154 patients with stenoses or occlusions lesions in the femoropopliteal segment, comparing paclitaxel DEB PTA, PTA with uncoated balloons and paclitaxel in the contrast media. In this study, the use of DEB was associated with significant reduction in angiographic

late lumen loss and need for repeated target lesion revascularization. **(Tepe et al., 2008)**

In 2008, Werk et al also randomized patients with occlusions or stenosis, restenosis, or in-stent restenosis lesions of femoropopliteal arteries to DEB PTA using paclitaxel-coated catheters versus conventional PTA. The angiographic restenosis rate was less in the patients treated with a drug-coated balloon.

This mechanism of delivery may enhance the overall vessel response to angioplasty by delivering a high dose of medication without sustained systemic exposure and without long-term inhibition of positive remodeling and subsequent late in stent thrombosis. **(Werk et al., 2008)**

In 2011, Schmidt had published the result of his study on efficacy of drug-eluting balloons (DEBs) in the treatment of long infrapopliteal lesions. He found that limb salvage rate in critical limb ischaemia after 1 year follow up was 95.6 % in mean lesions length 176 ± 88 mm. **(Schmidt et al., 2011)**

Schmidt et al has compared 3 months patency rate in this study and the patency rate in their previous study of treatment of long infrapopliteal lesions using plain old balloon angioplasty. They found that restenosis rate in DEBs was 27% while restenosis rate in plain old balloon angioplasty was 69%. Moreover, restenosis after DEB was found to be focal, involving < 20% of

the length of the target lesion in more than 60% of the restenosed vessels. **(Schmidt et al., 2011)**

3. Cutting Balloon

A cutting balloon consists of a series of cutting blades (atherotomes) placed longitudinally along the surface of a standard angioplasty balloon. The cutting balloon (CB) was first designed and reported by Barath et al in 1991.

(Barath et al., 1991)

It was originally introduced for coronary intervention, but Cutting Balloon device (Boston Scientific Corp., Natick, MA) is also used also in tibial vasculature due to the same caliber. When inflated, these cutting blades score the lesion with incisions to facilitate dilatation of the vessel at relative low pressure (3 to 5 atmospheres), as shown in figure 28.

(Sumi and Ohki, 2010)

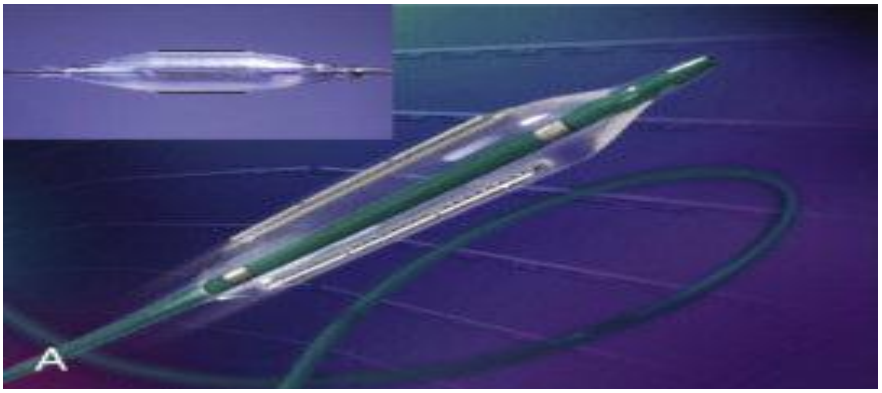


*Figure (28): shows Peripheral Cutting Balloon device (Boston Scientific Corp., Natick, MA) (***sumi and ohki, 2010***)*

It induced a controlled form of dissection rather than that was observed after standard percutaneous transluminal angioplasty. The longest balloon is only 2 cm, this relatively restricted range of balloon lengths that limit the therapy's potential applications. They are best suited for ostial lesions. **(Engelke et al., 2012)**

Cutting balloons have excellent technical success rates. Ansel and colleagues studied the outcome of treatment of 73 patients with critical limb ischemia by cutting balloons, and they reported that 1-year limb salvage rate was 86% with a low adjunctive stenting rate. **(Ansel et al., 2004)**

Dilation as well as deflation should be performed in a slow manner to allow extrusion and refolding of the blades in and from their protective sleeves. The incidence of vessel rupture was 0.8% (5 of 689 patients) compared with no occurrence after standard balloon angioplasty. **(Mauri et al., 2002)**

4. Cryoplasty

Cryoplasty devices induce controlled form of dilation and smooth muscle cell death (cell apoptosis) that results in less elastic recoil and negative (constrictive) remodeling, and less inflammatory response so less cell proliferation (less neointimal hyperplasia), figure 18. **(Allie et al., 2008)**

*Figure (29): shows PolarCath device (Boston Scientific Corp., Natick, MA). (Quoted from **sumi and ohki, 2010**)*

Bosiers and colleagues reported a prospective study on cryoplasty in treatment of 100 infrapopliteal lesions. Technical success was achieved in 95%. The 12-month limb-salvage rate of 93.8% but with primary patency rate was 55.9%. So, the authors concluded that cryoplasty was a safe and effective adjunct to PTA, and the wide-spread use of cryoplasty is not recommended. **(Bosiers et al., 2010)**

Stenting

Endovascular therapy with stents is now performed throughout the vascular system, including arteries from the intracranial circulation to the tibial arteries as initial therapy or as secondary treatment after failed balloon angioplasty.

(Schillinger et al., 2002)

As the use of endovascular stents has undergone more critical study, it has become evident that various vascular beds react

differently to stent placement which has implications for both short- and long-term results. When stent placement is anticipated, prophylactic antibiotics may be useful.

(Schillinger et al., 2002)

Indications :

The concept of primary stent placement appears to work best for some lesions that were treated with balloon angioplasty alone in the past with marginal results, including recurrent lesions, occlusions, and orifices lesions. **(Schneider, 2003)**

While, Indications for selective stent placement after balloon angioplasty includes residual stenosis, a persistent pressure gradient, and significant dissection. As the experience is gained with stents, indications for their placement have been modified continuously. Other relative indications include a significant ulceration, a long lesion, or a highly irregular, calcified plaque.

(Schneider, 2003)

Flow limiting dissection: Stents should be placed for any false channel or for any intimal flaps that impede flow, increase in size during the procedure, or extend into a previously uninvolved segment of artery.

Unfortunately, there is no good method of assessing the severity of dissection or predicting its behavior. Residual

stenosis after angioplasty: The concept of preventing recurrence by eliminating residual stenosis makes empiric sense. A 30% postangioplasty stenosis is used as a general threshold for stent placement. **(Schneider, 2003)**

Advantages

Stenting after percutaneous angioplasty improves short-term patency by improving PTA failure rate and long-term patency by providing a better technical result. The goals of stenting are to ensure an adequate lumen, and maintain adequate blood flow to the target organ. **(Sheridan et al., 2010)**

Disadvantages

Each stent application has its own cost and complications risks. The sheath must usually be upsized, a foreign body is implanted, the procedure time is often extended somewhat, and stents have their own unique complications. In addition, the cost of a single stent substantially increases the cost of an endovascular intervention. **(Schneider, 2003)**

Although stents are designed to maintain patency of the treated vessel, the presence of foreign material in the arterial bed may actually add to long-term failure through neointimal hyperplasia and vessel restenosis/ thrombosis. **(Farb et al., 1999)**

In-stent restenosis (ISR) is the major shortcoming of stent therapy; even with the innovation and promising benefits of drug-eluting stents. ISR is mainly caused by the interaction between the blood and the stent surface and a permanent mechanical irritation of the vascular tissue. **(Erne et al., 2006)**

Stent selection

Besides consideration of the various stent characteristics, selection of an appropriate stent depends upon plaque morphology, external forces, anatomic location, and branch locations. For the infrageniculate arteries, SE stents are used preferentially. **(Pearce and Jordan, 2010)**

The major characteristics that determine suitability of a stent are radial force, flexibility, and precision of deployment, including radiopacity. An ideal stent will conform to the vessel be easy to deliver with minimal sheath size, prevent acute failure of the procedure, provide long-term resistance to negative remodeling, be fracture resistant, and be easily visible.

(Grenacher et al., 2006)

Generally, stents are divided into two groups based on their construction and mode of deployment: self-expanding (SE) stents and balloon-expandable (BE) stents.

(Pearce and Jordan, 2010)

Balloon-Expandable stents are optimal in situations that demand precise deployment. So it can be used in treating ostial lesions.

(Arain and White, 2008)

Self-Expanding Stents (nitinol stents) have better vessel-matching characteristics based on the ambient temperature. This allows the length of the stent to be controlled dependably. Self-Expanding stents (SE) have less radial force and, conversely, improved elasticity. SE stents are also used preferentially in infrageniculate arteries to better accommodate variable vessel diameters. **(Sheridan et al., 2010)**

SE stents are better suited for tortuous lesions or those traversing vessels of variable diameter. These stents are more flexible than their BE counterparts. To maintain the stent in its constrained form during delivery to the lesion, the stent is covered by an outer sheath on the mounting catheter.

Actual deployment of the stent requires sequential removal of the constraining sheath from the distal end of the catheter (relative to the operator) to the proximal end. So, it is during this maneuver that the stent can “watermelon seed” in one direction or be retracted by the operator and lead to mal deployment of SE stents. **(Rogers and Laird, 2007)**

A SE nitinol stent has been developed for use in infrapopliteal arteries (Xpert stent, Abbott Vascular, San Francisco, CA). Tepe et al. reported data on a series of 18 patients receiving stents in infragenicular arteries.

Xpert stents were placed for PTA failure. The investigators had 100% initial technical success with no adverse events. 14 stented segments were evaluated at 6 months, with three occluded and one >50% restenosis at that time. And the remaining 10 stents were widely patent. **(Tepe et al., 2008)**

Peregrin et al. reported a prospective study of Xpert stent placement in patients with failed PTA of the infrapopliteal arteries and compared the results to patients undergoing successful PTA alone. At 12 months follow-up with Doppler ultrasound, patency in the PTA alone group was 82% while patency in the stent group was 78%. So, stent placement was a reasonable means of converting a technical failure to success in the treatment of patients with chronic critical limb ischemia.

(Peregrin et al., 2008)

Drug-Eluting Stents

Nowadays, the greatest problem concerning endovascular procedures in the crural arteries is the maintenance of angiographic patency. The rates of primary success and limb salvage are satisfactory. Unfortunately, the restenosis rates, after

a successful PTA in the infrapopliteal arteries in angiographic evaluation after 6– 12 months, are high**.**

(Schillinger et al., 2003)

Many modalities have been investigated to control the hyperplastic response to an arterial implant. Specifically, stents have become a conduit to deliver medication to the local vascular environment in an effort to limit this injury response. Three common chemotherapeutic agents have been attached to the stents: paclitaxel, sirolimus, and everolimus. These agents have been shown to aggressively inhibit the neointimal response and improve patency rates. **(Hiatt et al., 2002)**

Sirolimus is a naturally occurring macrolide antibiotic, but used widespread only for immunosuppression after transplants. Studies have demonstrated that it blocks the proliferation of smooth muscle cells and decreases T-cell proliferation.

(Rochier and Sumpio, 2010)

Everolimus is a therapeutic agent originally developed for the prevention of organ transplant rejection but is also effective at inhibiting the growth of certain tumors. It effectively inhibits experimental vascular smooth muscle cell proliferation and enhances vascular remodeling. **(Lammar et al., 2011)**

Paradoxically, these drug-eluting stents (DESs) have created a new late failure mode of delayed stent thrombosis as a result of

the lack of re-endothelialization and minimal incorporation into the associated vessel wall. The raw surface of the stent carries a risk of stent thrombosis as high as 4% after 1 year.

(Mauri et al., 2007)

Primary application of stents in the treatment of atherosclerotic lesions is an effective and safe method of restoring regular flow and achieving a good technical result for procedure. Besides, Angiographic analysis indicates a lower risk of restenosis by using sirolimus-eluting stents in comparison to standard stents.

(Falkowski et al., 2009)

In many studies,. Small studies using sirolimus- or paclitaxel eluting stents have been published to evaluate drug eluting stents in the infrapopliteal arteries.

Siablis et al, have conducted an important prospective study included patients with CLI who underwent infrapopliteal revascularization with angioplasty and “bailout” use of sirolimus eluting stent (SES) or Bare Metal Stents. Infrapopliteal application of SESs for CLI significantly improves angiographic long-term patency and reduces infrapopliteal vascular restenosis versus BMSs.

(Siablis et al., 2009)

Absorbable Stents

The long-term stent-vessel interaction can result in late failures and, ultimately, occlusion. One method under investigation to counteract this effect is the potential for stents composed of biodegradable material. The long-term benefit of stent implantation is attenuated after approximately 24 months. Absorbable stents in small sized arteries have shown a 30% reduction in neointimal hyperplasia at 12 months and a 60% reduction at 18 months. But the clinical effect of its degradation may lead to embolization with distal ischemia.

(Ormiston et al., 2008)

Tamai and associates used a poly-l-lactic acid (PLLA) bioabsorbable stent in the coronary arteries of 15 patients and reported a restenosis rate of 10.5% at 6 months.

(Tamai et al., 2000)

Ormiston and colleagues recently reported success in attaching everolimus to the PLLA stent to obtain the benefit of a medicated stent that reduces the intimal response while potentially removing the nidus for Late in Stent Thrombosis. These investigators found a decreased neointimal response and reduced cardiac events (3.3%) in a series of 30 patients with no LST. **(Ormiston et al., 2008)**

The absorbable metal stent (magnesium-alloy stent) was used in a study, evaluated the safety and performance of the first-generation AMS for treatment of infrapopliteal lesions in patients with CLI. The study had shown that the AMS is a safe technique to use for treating peripheral arterial disease, but the tested current-generation AMS did not show efficacy in long-term patency over standard PTA in infrapopliteal vessels.

(Bosiers, 2009)

Carbofilm-coated have gained some attention in the infrapopliteal arteries as well based on their success in the coronary circulation. Infrapopliteal Carbofilm stent application has higher patency rates than PTA alone at 6 months follow up.

(Rand et al., 2006)

Complications of angioplasty

Despite major advances during recent years, complications in peripheral vascular interventions remain a major issue. So, Strategies for prevention and management of complications are a major goal in education and training of interventionists. Complications are reported to occur in 2–6% of cases.

(**Schillinger, 2007**)

Patients with critical limb ischemia often have multiple lesions in the crural vessels, with coronary heart disease and a lot of

comorbidities, identifying them as high-risk patients. The natural history of patients with rest pain alone carries a 5-year mortality rate about 50 %. (**Minar and Graziani, 2007**)

Complications can be classified according its sequel as: minor complications which need no or nominal therapy with no consequences, and major complications which almost need major unplanned therapy with permanent adverse sequel and may lead to death. (**Schillinger, 2007**)

Complications can be classified according its site into systemic and local complications. Then local complications are classified into angioplasty site complications, distal vessels to angioplasty site complications and access site complications (mostly groin) which represent the most common complications.

(**Kamineni et al., 2005**)

Systemic complications include renal failure due to contrast nephropathy, infection with septicemia, myocardial infarction, and stroke. (**Schillinger, 2007**)

Contrast-induced acute renal failure is due to the high prevalence of diabetes in these patients. Dorros et al studied aconsecutive series of 284 patients treated for critical limb ischemia. 20 patients (7%) developed renal failure.

(**Dorros et al., 2001**)

The most frequent complications, involve the vascular access site (4%), which are Bleeding and hematomas (3.4%), false aneurysm (0.5%), arteriovenous fistula (0.1%), and infection. These complications increase in incidence if ipsilateral antegrade access is used in obese patients with iliofemoral disease. These complications can be substantially reduced by decreasing diameters of sheaths, low-traumatic puncture techniques, adequate interventional imaging modalities, and modern closure devices. (**Mlekusch et al., 2006**)

With improving technology (development of low-profile non-compliant balloons, miniaturization of the balloon catheters, introduction of vascular stents), ANGIOPLASTY SITE complications have decreased in frequency to (3.5%). These complications include acute vessel thrombosis, vessel dissection, perforation, and distal embolization.

(**Schillinger, 2007**)

The appropriate choice of balloon size according to the diameter of the artery (diameter and length) is of critical importance to avoid severe dissections or vessel perforation/rupture. Arterial occlusions may occur due to dissection, spasm, or distal embolization. The embolic occlusion of distal tibial or pedal arteries may severely deteriorate the already existing ischemia. Arterial perforations caused either by the guidewire inadvertent placement in a small collateral vessel or at the site of

angioplasty. Major local bleeding may cause compartment syndrome. (**Minar and Graziani, 2007**)

Tibial vessels have a significant propensity for spasm, especially in younger patients without calcification. Hayes et al have reported that the risk of perforation is significantly increased with subintimal angioplasty technique. (**Hayes et al., 2002**)

Perforation requires temporary balloon occlusion for a few minutes. Furthermore, inflation of a blood pressure cuff in the region of the vessel perforation can also be recommended to support rapid sealing of the perforation. If angiography demonstrates further blood extravasation, implantation of a bare metal or even covered stent may become necessary.

(**Minar and Graziani, 2007**)

Acute thrombosis occurred in 2–4% of cases with balloon angioplasty in the pre-stent era. Angiographic characteristics associated with acute thrombosis with balloon angioplasty included long lesions, dissection, use of oversized balloons relative to the reference segment, residual stenosis >50%, intraluminal thrombus, and multivessel disease.

(**Heuser and Biamino, 2005**)

The incidence of thrombosis in peripheral interventions could be dramatically reduced by the introduction of dual antiplatelet

therapy combining aspirin and thienopyridines, and then it is encountered in less than 2% of the cases.

(**Schillinger et al., 2007**)

Stenting has essentially decreased abrupt closure at the end of a procedure to <1%.however, Stents fail to achieve a full endothelial lining that can lead to restenosis. Intimal hyperplasia is the predominant cause for restenosis after angioplasty and stenting. (**Trabattoni and Bartorelli, 2008**)

Complications at vessel segments distal to the target site (2.7%) include distal dissections and Peripheral embolization. Device-related complications during interventions (broken wires, malfunctioning stents, and embolization of catheter shaft material) are infrequent, although it has been reported in almost all vessel areas. (**Schillinger, 2007**)

Patients and methods

Patients and methods

This is a **prospective study** including 112 patients with critical lower limb ischemia due to both isolated infra-popliteal disease and infrapopliteal disease with proximal superficial femoral artery disese . Patients were treated by angioplasty (± stenting) in Kasr Alainy hospital in the period from october 2012 to October 2013.

Inclusion criteria: Patients with documented lesions of tibial vessels and patients with concomitant SFA lesions by means of an imaging modalities (duplex, CTA or angiography) and indicated for endovascular intervention and have salvageable limbs.

Exclusion criteria: PAD not related to atherosclerosis e.g. vasculities, embolic disease and the non-salvageable limbs with massive tissue loss that indicated for 1ry amputation.patients with popliteal lesions and proximal iliac lesions were also excluded.

Patients with tibial occlusive disease presented to the vascular department of **KASR ALAINY hospital** through one year were divided into two groups:

***The group A**: patients with isolated infrapopliteal occlusive lesions.

***The group B**: patients with combined infrapopliteal and proximal superficial femoral occlusive lesions.

Patients underwent full history taking and detailed vascular examination. Patients had routine laboratory investigations including blood sugar,lipid profile, liver and kidney functions , arterial duplex examination .

Data were collected including age, sex , risk factors for peripheral arterial disease e.g. “ smoking , Diabetes or hyperlipidemia” , serum creatinine level , patient complaint : “ gangrene , ulcer or rest pain “

The morphology of infrapopliteal lesions was evaluated in each vessel regarding number , length of the lesion and whether it is occlusion ,stenosis or there is no distal run off .

The interventions done for all patients were analyzed identifying the dilated vessels , the amount of dye used , technical success and the presence of palpable pulse immediately following intervention .

The outcome for all patients will be assessed focusing on the following end points:

A-Technical sucess (clinical or angiographic).

B-Follow up for patency at 3, 6 months and 1 year.

C-limb salvage and mortality.

Limb salvage was defined as freedom from major amputation, i.e. , any amputation above the level of the ankle.

Data were statistically described in terms of range, mean ± standard deviation (± SD), median, frequencies (number of cases) and percentages when appropriate. Comparison of quantitative variables between the study groups was done using Mann Whitney *U* test for independent samples. For comparing categorical data, Chi square ($\chi 2$) test was performed.

Exact test was used in stead when the expected frequency is less than 5 A probability value (*p* value) less than 0.05 was considered statistically significant. All statistical calculations were done using computer programs Microsoft Excel 2003 (Microsoft Corporation, NY,USA) and SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago,IL, USA) version 15 for Microsoft Windows.

Results

Results

In this current study included 112 patients underwent percutaneous transluminal angioplasty of tibial vessels and were divided into 2 groups, **group A** (46 patients)which contains patients with isolated infrapopliteal disease and **group B** (66patients) which contains patients with concomittant proximal SFA lesions.

The demographic features

The demographic features of the studied sample are shown in table (R1) demonstrate that most of the included patients sample were males (58.9%)while only (41.1%) were females making the sample unequally distributed. The age ranged from 40 years up to 83 years old with a median value of 66 and a mean of 64.58with standard deviation (SD) of 7.63.

	Minimum	Mean	Std. Deviation	Median	Maximum
age	40.00	64.5893	7.63415	66.0000	83.00

Table(2) demographic data

In both groups the demographic data as regards the male tofemale ratios were shown in table

Sex	sites of lesions		Total
	infrapopletial	SFA+infrapopletial	
Male	22(33.3%)	44(66.7%)	66
Female	24(52.2%)	22(47.8%)	46

Table(3)sex varient

The comorbidities distribution among both groups

1. Diabetis :

In group (A) the diabetic patients were 42(91.3%) and non diabetic patients were 4 (8.7%).

In group (B) the diabetic patients were 64(97%) and non diabetic patients were 4 (3%).

Diabetic affection of both groups shows no statisical significant (p0.226)

Diabetes	sites of lesions	
	infrapopletial	SFA+infrapopletial
	42(91.3%)	64(97.0%)

Tabple(4)diabetes varient

2. Hypertension :

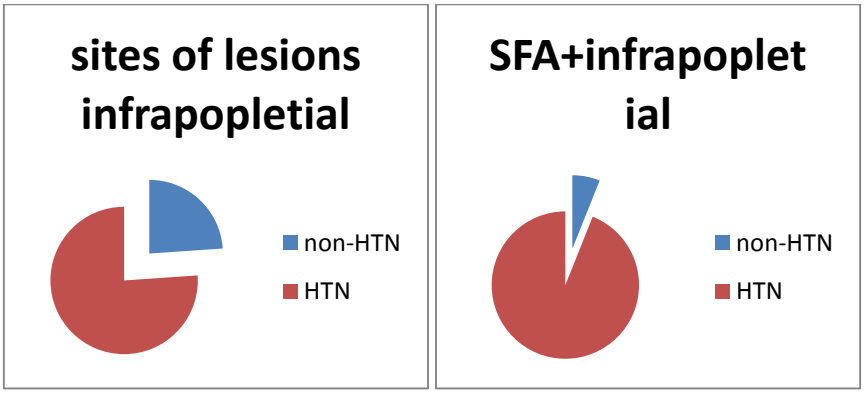


Fig (30)Hypertension in both groups

In group (A) the hypertensive patients were 35(76.1%) and non hypertensive patients were 11 (23.9%).

In group (B) the hypertensive patients were 62(93.9%) and non hypertensive patients were 4 (6.1%).

There is statistical significance for hypertension affection for patients in both groups.(p-0.014)

3. smoking :

In group (A) the smoking patients were 21(45.7%) and non smoking patients were 25 (54.3%).

In group (B) the smoking patients were 43(65.2%) and non smoking patients were 23 (34.8%).

There is statistical significance for smoking for patients in both groups (p0.050)

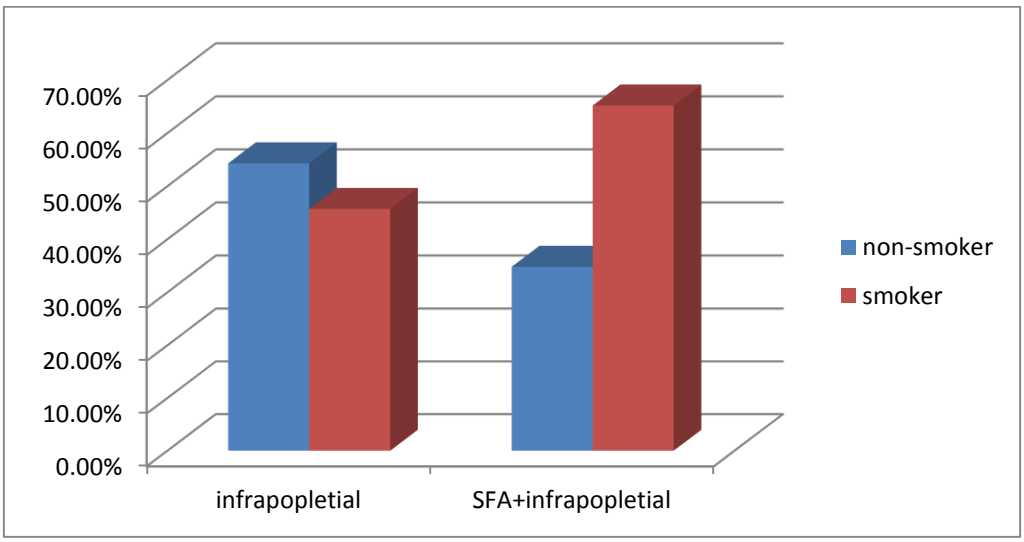


Fig (31)Smoking in both groups

For other comorbidities e.g cardiac diseases,chest diseases ,renal disease and CVS problems ,the statistical analysis for all data collected from both groups shows no statistical significance.

The clinical presentation analysis

		sites of lesions		P value
		infrapopletial	SFA+infrapopletial	
Rest pain		26.1%	80.3%	0.492
Minor tissue loss		39.1%	53.0%	0.180
Major tissue loss		32.6%	25.8%	0.524
Tasc classification	B	0%	1.5%	0.344
	C	30.4%	40.9%	
	D	69.6%	57.6%	
Type of lesion	stenosis	15.2%	18.2%	0.636
	occlusion	84.8%	80.3%	

Table (5)Clinical presentation varients

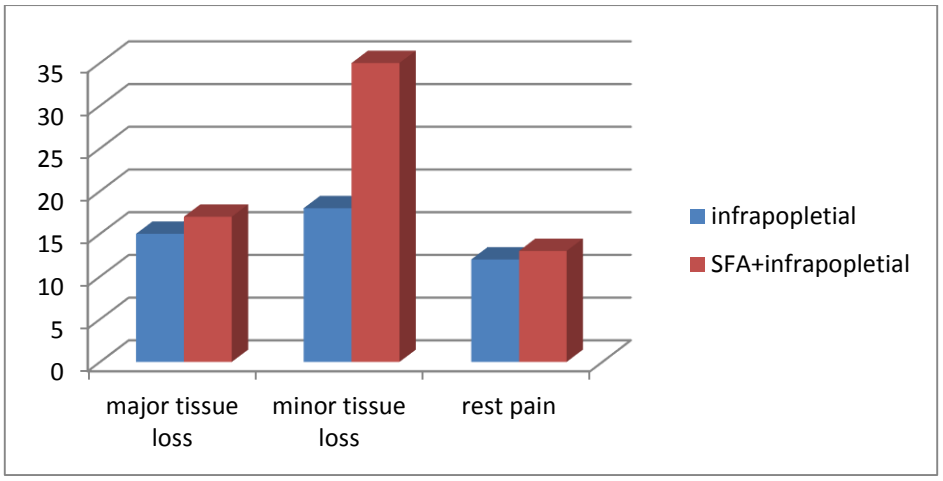


Fig (32)Clinical presentation

The Runoff state of all cases was studied and shows the followings:

	sites of lesions		p-value
Run-off	infrapopletial	SFA+infrapopletial	
0	2(4.3%)	7(10.6%)	0.461
1	27(58.7%)	32(48.5%)	
2	9(19.6%)	11(16.7%)	
3	8(17.4%)	16(24.2%)	

Table (6)Run-off vessels number

single vessel runoff	sites of lesions		p-value
	infrapopletial	SFA+infrapopletial	
PTA	6(13.0%)	10(15.2%)	0.300
ATA	18(39.1%)	15(22.7%)	
Peroneal	3(6.5%)	7(10.6%)	

Table (7) Run-off vessel

Follow up results

Follow up of all cases in 3,6,12 months for patency ,limb salvage and amputation revealed the followin data,

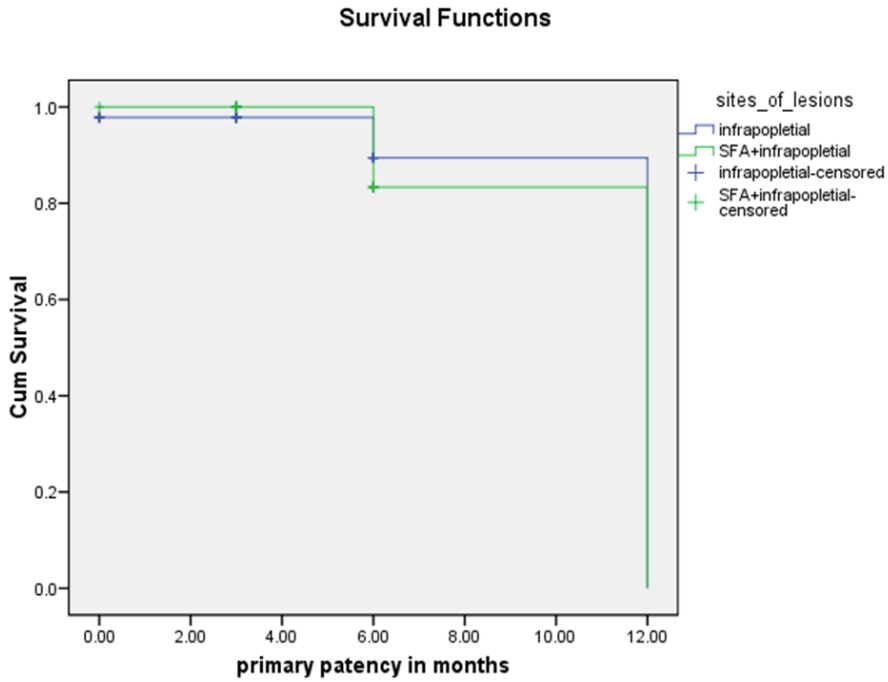
Primary patency of all cases was studied and showed the followings:

Follow-up		3 months	6 months	12months
group A	patent	42	35	14
	failed	4	11	25
group B	patent	65	55	38
	failed	1	11	22
p - value		0.157	0.347	0.607

Table (8) primary patency

No ststistical significance in **the primary patenct** in both groups.

Fig (33) Kaplen miere function curve



Limb salvage:

No ststistical significance in **limb salvage** in both groups.

limb salvage	sites_of_lesions		p-value
	infrapopletial	SFA+infrapopletial	
3months	43 (93.5%)	65 (98.5%)	0.304
6months	37 (80.4%)	54 (81.8%)	1.000
12months	29 (63.0%)	45 (68.2%)	0.608

Table (9)Limb salvage

Major amputations

		group A	group B
major amputation	BKA	10	14
	AKA	0	1
p - value	0.703		

Table (10) Amputations

No ststistical significance in **major amputation** in both groups.

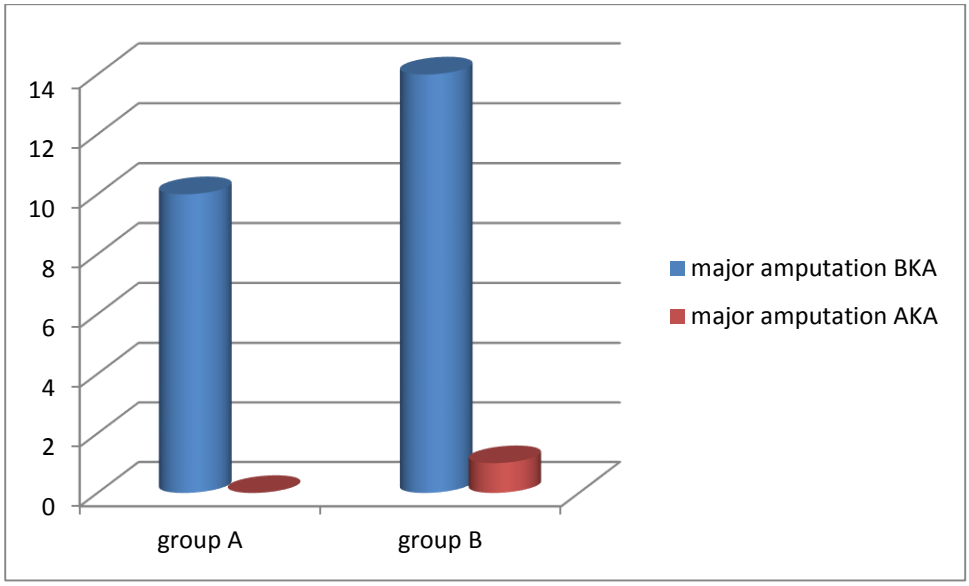


Fig (34) major amputations in both groups.

Morphology of the lesions(stenotic or occlusion) has impact on the amputation rate as following

	type of lesion		
	stenosis	occlusion	both
limb salvage	18	69	0
AKA	0	0	1
BKA	1	23	0
p-value	0.001		

Table (11) Effect of lesion morphology

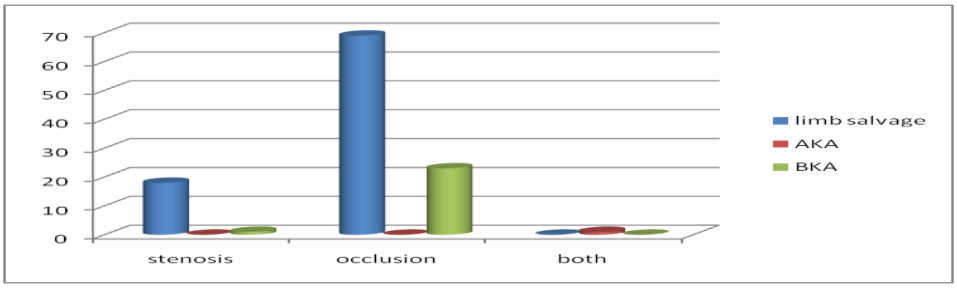


Fig (35) Morphology of the lesions

The site of tibial angioplasty : performed showed some statistical significant values on the post angioplasty follow up as shown in these tables and graphs

	sites of lesions		p-value
Angioplasty	infrapopletial	SFA+infrapopletial	
ATA	18(39.1%)	25(37.9%)	0.025
PTA	11(23.9%)	25(37.9%)	
Peroneal	3(6.5%)	10(15.2%)	
ATA+PAT	7(15.2%)	3(4.5%)	
ATA+peroneal	4(8.7%)	0(.0%)	
PTA+peroneal	3(6.5%)	3(4.5%)	

Table (12) distribution of the angioplasy vessels.

limb salvage	sites__of_tibial_angioplasty						p-value
	ATA	PTA	Peroneal	ATA +PAT	ATA+peroneal	PTA+peroneal	
3 months	41 (95.3 %(	36 (100. 0%)	12 (92.3 %)	10 (100. 0%)	3 (75.0%)	6 (100.0%)	0.154
6 months	37 (86.0 %)	32 (88.9 %)	4 (30.8 %)	9 (90.0 %)	3 (75.0%)	6 (100.0%)	0.001
12 months	28 (65.1 %)	27 (75.0 %)	3 (23.1 %)	7 (70.0 %)	3 (75.0%)	6 (100.0%)	0.002

Table (13) limb salvage

	sites__of_tibial_angioplasty					
	ATA	PTA	Peron.	ATA+PTA	ATA+peron	PTA+peron
AKA	0	1	0	0	0	0
BKA	8	4	10	1	1	0
p-value	0.001					

Table (14) major amputations

passage route	sites of lesions		p-value
	infrapopletial	SFA+infrapopletial	
intraluminal	40 (87.0%)	49 (74.2%)	0.153
subintimal	6 (13.0%)	17 (25.8%)	

Table (15) passage route

Discussion

Discussion

Critical limb ischemia (CLI) is a manifestation of peripheral arterial disease (PAD) that describes patients with typical chronic ischemic rest pain or patients with ischemic skin lesions, either ulcers or gangrene. The term CLI should only be used in relation to patients with chronic ischemic disease, defined as the presence of symptoms for more than 2 weeks.

(Norgern et al., 2007)

The primary goals of treatment for critical limb ischemia (CLI) are alleviation of ischemic rest pain, healing of arterial insufficiency ulcers, and improving quality of life. These goals are directed toward preventing limb loss and CLI-related mortality. Arterial revascularization serves as the foundation of a contemporary approach to promote amputation-free survival.

(Bunte , Shishehbor ,2013)

If the critical limb ischaemia is not revascularized, Up to 40% of extremities with ischemic nonhealing ulcers, gangrenous digits, or rest pain may require a major amputation within 6 months of onset. **(Tefera et al., 2005)**

In 2012, Schamp et al performed a literature study about the published articles focused on revascularization of infrapopliteal vessels till September 2011. They found that angioplasty and bypass surgery have similar limb salvage rate of approximately

80% at 3-year follow-up. While, patency rates appear to be higher after surgery. And they concluded that both modalities are likely to be complementary. **(Schamp et al., 2012)**

In 2013, Söderström and associates concluded that infrapopliteal percutaneous angioplasty can be an effective first-line strategy achieving similar long-term results as bypass surgery in patients with critical limb ischemia.

They observed that PTA and bypass surgery achieved similar 5-year limb salvage (75.3% vs 76.0%), similar survival (47.5% vs 43.3%), and amputation-free survival (37.7% vs 32.7%) in 1073 patients complaining of CLI with infrapopliteal disease. **(Söderström et al., 2013)**

Recent advances in endovascular technology favor the endovascular treatment to replace the open surgical procedures as the first line of treatment for many infrapopliteal arterial lesions. Because no vascular intervention, either endovascular or surgical, is durable forever, there is always the possibility that the patient may require additional interventions in the future.

(Sumi and ohki, 2010)

Improvements in wires, balloons and chronic total occlusion (CTO) crossing catheters have resulted in increased balloon angioplasty in CLI and improved its outcomes. The lower

profile catheters have further expanded balloon angioplasty into CLI and tibial arteries.

(Allie et al., 2010)

“Situational perfusion enhancement” can explain the relatively high limb salvage rate in comparison with lower patency rate. That there is a population of asymptomatic patients with subclinical lower extremity ischemia and very low perfusion pressures.

These patients become symptomatic only when they develop incidental foot ulceration and do not have the circulatory reserve to heal boost in arterial perfusion, even transiently, usually allows healing of the ulcer. Once the ulcer is healed, maintenance of enhanced perfusion is not critical, and recurrent ischemia is usually well tolerated as the patient resumes the subclinical ischemic state.

(York and Taylor, 2010)

In our study the age of the patient was ranging from 40 to 83 years most of them were males 58.9% indicating increased incidence of tibial disease in males however Keeling et al had the females representing most of the cases 53% of his 76 patient study. **(Keeling etal. , 2009)**

In our study most of our patients are diabetic in group A represent 91.3% and in group B 97% and diabetes shows no statistical significant P-value (p0.226) . Diehm et al concluded that diabetes is an obvious risk factor in below the knee atherosclerotic lesions most likely due to the fact that diabetes produces microvascular disease**.** **(Diehem et al. , 2006)**

Between March 2002 and May 2008, infrapopliteal angioplasty was performed on 108 limbs of 93 patients with CLI. Median follow-up was 30 months. The number of diabetic patients was 70 (75%). There were no significant differences between the diabetic group and non-diabetic group in technical success rate (66% vs. 84%, P = 0.133) and primary clinical success rate (81% vs. 92%, P = 0.234).

Kaplan-Meier analysis showed that diabetic patients had a higher frequency of poor primary patency (P = 0.012) during 2-year follow-up, but that there were no significant differences between the 2 groups in terms of limb salvage (P = 0.930), and survival (P = 0.459).

(Ryu et al,2012)

Other risk factors as **s**moking & hypertension in our study were significantly higher in group B patient (p0.014), Diehem et al. also concluded that hypertension and cigarette smoking increased disease proximal arteries more than below knee arteries. **(Diehem et al. , 2006)**

Infrapopliteal disease is more extensive that it affects both anterior tibial artery and posterior tibial artery mainly. Most centers usually attempted to provide direct straight line inflow to the foot through anterior tibial artery for ischemic forefoot lesions and through posterior tibial artery for calcanear lesions.

(Graziani et al., 2007)

In our study tibial disease in both groups involves mainly anterior tibial artery(38.4%)and posterior tibial artery (32.1%),with 18% stenotic lesions and 82% occlusive lesions.In 12 months follow up in group A 10 major amputations performed and in group B 15 major amputations done.Limb salvage rate was 96.3% in 3 months,81.3% in 6 months and 66.1% in 12 months and 11.6% lost follow up.

Schmidt et al, angioplasty was performed in 77 infrapopliteal arteries of 62 limbs of 58 CLI patients with treated arteries were stenosed in 35.1% and occluded in 64.9%. In 15months, minor amputations were 8.1%. **(Schmidt et al., 2010)**

A retrospective study was performed in 90 consecutive patients to determine the effectiveness of infrapopliteal PTA in treating CLI. In 90 limbs, there were 57 infrapopliteal stenoses and 104 occlusions. In all patients, there were 5 amputations after the first year. **(Odink et al., 2012)**

Strom et al,during evaluation the amputation-free survival after below the knee percutaneous transluminal angioplasty in a consecutive group of patients with critical ischemia of the lower extremity. A total of 70 consecutive patients with critical ischemia were treated with below the knee percutaneous transluminal angioplasty at the vascular center at Rigshospitalet with the purpose of limb salvage.

All patients were deemed unfit for major surgery due to anatomical limitations or severe co-morbidity, and no prior attempts of revascularization were performed. Follow-up clinical examinations were performed within 6 weeks and after 1 year. A total of 15 major amputations were performed during follow-up, with 11 amputations performed within the first year.

Complications after percutaneous transluminal angioplasty were rare. Cumulative mortality after 1 and 2 years was 22% and 34%, respectively. Amputation-free survival at 1 and 2 years of follow-up was 68% and 58%, respectively. **(Strom et al,2015)**

In a review of the literature in 2010 and 2011, it revealed that balloon angioplasty of the tibial arteries in patients with critical limb ischemia carried a 1-year limb-salvage rate of 75% to 100%. Balloon angioplasty considered as the main endovascular treatment modality for infrapopliteal disease, even with severe

disease. There is no evidence that primary stenting improves patency or limb salvage compared to PTA alone.

(Rana and Gloviczki, 2012)

In a retrospective analysis of 1,445 angioplasty procedures, Peregrin recommended that PTA should be performed to open up as many arteries as possible, even in TASC D lesions to improve outcomes. Moreover, repeated PTA is capable of keeping the long-term (5-10 years) Limb Salvage rate close to 75 %. **(Peregrin et al., 2010)**

Giles et al conducted a study on 176 consecutive limbs (163 patients) which underwent infrapopliteal angiopasty for CLI from February 2004 to March 2007. Stents were placed in infrapopliteal vessels in 15 limbs (8%). **(Giles et al., 2008)**

In our study there was 1 mortality during follow up and 11.6% lost follow up in one year follow up . In the prospective study done by keeling et al. , there were 12 mortalities during follow up (16%) . **(Keeling et al. , 2009)**

Patients who undergo multilevel intervention involving the tibial vessels exhibit improved patency compared with those who undergo intervention for lesions isolated to the tibial vessels. This may reflect increased distal disease burden for patients who undergo isolated tibial intervention. The study data suggest that the presence of multilevel disease should not preclude an

attempt at percutaneous revascularization.Further study is required before formulating definitive recommendations for the endovascular treatment of tibial vessel disease.

(Peregrin et al., 2010)

Objective performance goals (OPGs) are a set of standardized end points generated from well documented historical controls against which new therapeutic procedures may be compared in single-arm studies. **(Varela et al,2014)**

A retrospective study of 121 infrapopliteal endovascular procedures. The tibial intervention was combined with a femoropopliteal angioplasty in 70 procedures. Major adverse cardiovascular events (MACEs), major adverse limb events (MALEs), and major amputations at 30 days were recorded as safety outcomes. Freedom from any MALE or perioperative death (Freedom from MALE + POD) and amputation-free survival were calculated as primary efficacy end points at both 12 months and at 8 years.

The incidence of MACEs, MALEs, and amputation at 30 days were 5%, 2.5% and 1.7% respectively. Freedom from MALE + POD of 76% and an amputation-free survival of 78% at 12 months. Freedom from MALE + POD and amputation-free survival at 8 years decreased to 60% and to 26% respectively.

(Varela et al,2014)

In a review of the literature, patients undergoing primary infrapopliteal PTA from March 2002 to June 2006 were included. Primary study end points were primary patency, assisted patency, limb salvage, and patient survival assessed by Kaplan-Meier life-table analysis.

There were 155 PTAs undertaken in 144 patients, with critical limb ischemia (86%), diabetes (66%), and renal insufficiency (45%). Infrapopliteal lesions were classified as TransAtlantic Inter-Society Consensus A (7%), B (18%), C (39%), and D (35%). PTA was confined to the infrapopliteal segment in 40 (26%), and 115 (74%) underwent multilevel treatment. Five patients (3%) received stents.

Technical success was 95%. The 30-day mortality was 2%, and major morbidity was 3%. The mean follow-up was 22 months. The 40-month actuarial primary patency was 62% (standard error, 5%). Of the 42 unhealed ulcers, 15 (13%) required major amputations for a 40-month limb salvage of 86.2%.

(Conrad,et al,2009)

Patency and limb salvage rates for endovascular treatment of tibial vessel disease in this study are comparable with those with multilevel lesions mainly in the SFA.Our study shows that there is no statisical significance in patency and limb salvage in both groups during the time of follow up (3,6,12months).

We could not prove any difference between both groups,though we noticed a high LIMB SALVAGE rate in group B,but it was ststistically insignificant.This could be related to low number of patients in group A or the patient lost for follow-up.

From November 2002 to February 2008, **Sadek et al**, evaluated the overall efficacy of endovascular intervention for tibial vessel disease and whether the requirement for single-level compared with multilevel intervention affected outcomes. The primary end points evaluated were technical success, limb salvage, primary patency, and secondary patency.

The study comprised 85 patients, 89 limbs, and 114 procedures. The technical success rate for all procedures was 91%. Limb salvage rates for patients with critical limb ischemia at 6, 12 and 18 months were 85%, 81%, and 69% respectively. For the complete patient cohort, primary patency rates at 6, 12 and 18 months were 68%, 50%, and 37% respectively. Multilevel intervention was associated with significantly improved secondary patency compared with single-level intervention (P = .045). This may reflect increased distal disease burden for patients who undergo isolated tibial intervention.

The study data suggest that the presence of multilevel disease should not preclude an attempt at percutaneous

revascularization. Further study is required before formulating definitive recommendations for the endovascular treatment of tibial vessel disease. (**Sadek ,et al,2009)**

Conclusion

Conclusion

Critical limb ischemia (CLI) represents the extreme of the peripheral arterial occlusive disease spectrum and is associated with high mortality. Limb salvage often requires infrapopliteal revascularization by either angioplasty or bypass surgery. The past decade has witnessed a paradigm shift in CLI management toward endovascular treatment.

Infrapopliteal angioplasty can be performed safely with favorable results in patients with limited longevity. Primary patency is related to disease extent. Secondary interventions may be necessary to maintain clinical success. These data indicate that PTA should be considered as initial therapy for infrapopliteal occlusive disease in patients with lower extremity ischemia.

In this study , we compared the results of angioplasty of the isolated tibial lesions versus the combined SFA lesions with tibial disease. Through our work up and the data collected we didn`t find statistically significant difference between the group of patients who had isolated tibial lesions and those who had combined tibial disease and proximal SFA lesions in the form of limb salvage and patency rate.

Risk factors as **s**moking & hypertension in our study had significant effect on patients with proximal lesions.So,control

of these risk factors may improve the outcome of post intervention angioplasty.

Occlusive lesions shows statistically significant figures in terms of patency and limb salvage rates in relation to occlusive lesions.

Post-intervention pulse is more frequently palpable in the group of more than one vessel angioplasty but we found that the post intervention pulse whether palpable or not didn’t affect the outcome or the limb salvage rate .

Below the knee percutaneous transluminal angioplasty in patients with critical limb ischemia is a safe procedure in relieving critical ischemia, reducing the short-term rate of a major amputation.

Higher number of patients and long duration of follow up may be needed to further study the outcome in multilevel disease infront of isolated tibial lesions.

Summary

Summary

Peripheral arterial disease (PAD) is a progressive chronic debilitating disease which is prevalent in diabetic elder people. Critical limb ischaemia (CLI) is severe form of PAD with a high risk of major amputation, disability and death.

Moreover, the relative high mortality and morbidity, which associated with short distal bypass surgery, led interventionist to invest in and develop endovascular treatment in these patients. Interventionists had overcome arterial spasm by usage of thin guide wires (0.014 and 0.018 inch guide wires) and intraarterial administration of nitroglycerin.

Endovascular therapy is still considered as a first-line of treatment options for patients suffering from critical limb ischemia with infrapopliteal arterial occlusive disease by easily revascularizing inflow and outflow lesions with minimal morbidity and mortality. It has the ability to significantly improve distal extremity perfusion pressure with high technical success rates.

In patient with rest pain, tissue loss and ulceration, angioplasty is now commonly regarded as the first line of therapy if possible before proceeding to distal reconstruction. Many such patients have significant comorbid disease and are at high risk from general anaesthesia. Crural angioplasty can be performed

without compromise to potential distal graft anastomoses and has a very low associated morbidity and mortality.

The objective of below-knee limb salvge angioplasty is to restore " in– line " flow to the foot arches if possible. By using conventional 5 Fr systems,vessels down to 3 mm diameter can be treated. The availability of low profile balloons based on 0.018 and 0.014 inch guidewire allows balloon dilatation of vessels as small as 2mm in diameter. Also the technological development in angioplasty equipements allowed the use of many devices in tibial angioplasty including atherectomy devices (Silverhawk and Rotablator) , Cutting balloon , Angiosculpt balloon, Frontrunner catheter, Cryoplasty and the use of Excimer Laser .

Balloon inflation times and guide wire manipulations should be kept to a minimum to reduce the risk of vessel spasm and acute closure.

Post-intervention pulse is more frequently palpable in the group of more than one vessel angioplasty but we found that the post intervention pulse whether palpable or not didn’t affect the outcome or the limb salvage rate .In other patients there may be factors that necessitate doing single vessel angioplasty to avoid any jeopardize of the corrected vessel and avoid exposure of the patient to a lengthy procedure and large amount of dye .

In this study , we didn`t find statistically significant difference between the group of patients who had isolated tibial lesions and those who had combined tibial disease and proximal SFA lesions in the form of limb salvage and patency rate.

Risk factors as **s**moking & hypertension in our study had significant effect on patients with proximal lesions.So,control of these risk factors may improve the outcome of post intervention angioplasty.

References

References

1. Adam DJ, Beard JD, Cleveland T, et al. BASIL trial participants. Bypass versus angioplasty in severe ischaemia of the leg (BASIL): multicentre randomised controlled trial. Lancet. 2005; 366: 1925–1934.
2. Airoldi F, Vitiello R, Losa S, et al. Retrograde Recanalization of the Anterior Tibial Artery following Surgical Vessel Exposure: A Combined Approach for Single Remaining Infragenicular Vessel. J Vasc Interv Radiol. 2010; 21: 949-950.
3. Alexandrescu VA, Hubermont G, Philips Y, et al. Selective primary angioplasty following an angiosome model of reperfusion in the treatment of Wagner 1-4 diabetic foot lesions: practice in a multidisciplinary diabetic limb service. J Endovasc Ther. 2008; 15: 580-593.
4. Allie DE, Hebert CJ, Lirtzman MD, et al. Critical limb ischemia: a global epidemic.A critical analysis of current treatment unmasks the clinical and economic costs of CLI. Eurointervention. 2005; 1: 75-84.
5. Allie DE, Hebert CJ, Mitran EV, et al. Critical limb ischemia. Textbook of Peripheral Vascular Interventions. The United Kingdom: informa; 2008(2): 639-647.
6. Anderson A, McManus DD, and Fisher DZ. peripheral

vascular disease. United States of America: jones and Bartlett publishers; 2013.

7. Ansel GM, Sample NS, Botti III CF Jr, et al. Cutting balloon angioplasty of the popliteal and infrapopliteal vessels for symptomatic limb ischemia. Catheter Cardiovasc Interv. 2004; 61:1-4.
8. Arain SA, and White CJ. Endovascular therapy for critical limb ischemia. Vasc Med. 2008; 13: 267-279.
9. Armouw BS, Woollery T, Malarcher A, et al. Centers for Disease Control and Prevention (CDC). Annual smoking-attributable mortality, years of potential life lost, and economic costs--United States, 1997-2001. MMWR Morb Mortal Wkly Rep. 2004; 54:625-628.
10. Aspelin Patel, Stephen MacMahon, John Chalmers, et al. Intensive Blood Glucose Control and Vascular Outcomes in Patients with Type 2 Diabetes. The ADVANCE Collaborative Group: N Engl J Med 2003; 358:2560-2572.
11. Attinger C, Cooper P and Blume P. vascular anatomy of the foot and ankle in Textbook of Peripheral Vascular Interventions. The United Kingdom: informa; 1997(2): 639-647.
12. Ayraldi LM and Hodgson DJ. Peripheral endovascular interventions. New York: Springer Science+Business Media, LLC; 2005(3): 305-318.

13. Barath P, Fishbein MC, Vari S, and et al. Cutting balloon: A novel approach to percutaneous angioplasty. Am J Cardiol. 1991; 68:1249–1252.
14. Bates TA, Havens J, Belkin M, et al. Statin therapy is associated with improved patency of autogenous infrainguinal bypass grafts. J Vasc Surg. 2004; 39: 1178-1185.
15. Baweja G and Heuser RR. Recanalization devices for chronic total occlusions (including optical coherent reflectometry). In: Heuser RR and Henry M, eds. Textbook of Peripheral Vascular Interventions. The United Kingdom: informa; 2008(2): 92-99.
16. Berger JS, Roncaglioni MC, Avanzini F, et al: Aspirin for the primary prevention of cardiovascular events in women and men: a sex-specific meta-analysis of randomized controlled trials. JAMA 2006; 295:306-313.
17. Biondi-Zoccai GG, Agostoni P, Sangiorgi G, et al. Mastering the antegrade femoral artery access in patients with symptomatic lower limb ischemia: learning curve, complications, and technical tips and tricks. Catheter Cardiovasc Interv. 2006; 68: 835-842.
18. Boallack Williams, Richard LM Newell. gray s anatomy; anatomical the basis of clinical practice. Susan standring , ELSEVIER CHURCHILL LIVINGSTONE 39 th edition. section 8, chapter 114, page 1500-1503,2009.

19. Boisiers M, Hart JP, Deloose K, et al.Endovascular therapy as the primary approach for limb salvage in patients with critical limb ischaemia: experience with 443 infrapopliteal procedures. Vascular 2006; 14:63-9.

20. Bolia A, Brennan J, and Bell PR. Recanalisation of femoro-popliteal occlusions: improving success rate by subintimal recanalisation. Clin Radiol. 1989; 40:325.

21. Bonow RO, Smaha LA, Smith SC,et al. World Heart Day 2002. The international burden of cardiovascular disease: responding to the emerging global epidemic. Circulation. 2002;106:1602-1605.

22. Bosiers M, Deloose K, Verbist J, et al. Update management below knee intervention. Minerva Cardioangiol. 2009; 57:117-129.

23. Bosiers M, Deloose K, Vermassen F, et al. The use of the cryoplasty technique in the treatment of infrapopliteal lesions for Critical Limb Ischemia patients in a routine hospital setting: one-year outcome of the Cryoplasty CLIMB Registry. J Cardiovasc Surg (Torino). 2010; 51:193-202

24. Bosiers M, Peeters P, D'Archambeau O, et al.Absorbable Metal Stent Implantation for Treatment of Below-the-Knee Critical Limb Ischemia: 6-Month Analysis. Cardiovasc Intervent Radiol. 2009; 32: 424-35.

25. Bradbury AW, Adam DJ, Bell J, et al. BASIL trial

Participants. Bypass versus Angioplasty in Severe Ischaemia of the Leg (BASIL) trial: Analysis of amputation free and overall survival by treatment received. J Vasc Surg. 2010; 51:18S-31S.

26. Brass DJ, Suryadevara S. Aspirin and clopidogrel: efficacy and resistance in diabetes mellitus. Best Pract Res Clin Endocrinol Metab. 2006; 23:375-388.

27. Bunte MC, Shishehbor MH. Treatment of infrapopliteal critical limb ischemia in 2013: the wound perfusion approach. Curr Cardiol Rep. 2013 Jun;15(6):363. doi: 10.1007/s11886-013-0363-

28. Carla GC, Lamberty BGH. The Arterial Anatomy of Skin Flaps. Edinburgh: Churchill Livingstone; 2002; 98:1352-1364.

29. Chung YG, Cook PA, McClinton MA, et al. Microarterial Anatomy of the Lesser Toe Proximal Interphalangeal Joints. J Hand Surg Am. 2008; 23: 256-260.

30. Collins R, Burch J, Cranny G, et al. Duplex ultrasonography, magnetic resonance angiography, and computerized tomography for the diagnosis and assessment of symptomatic, lower limb peripheral arterial disease: systematic review. BMJ. 2007; 334:1257.

31. Collins T and McMullan PW Jr. Percutaneous transluminal angioplasty. In: Heuser RR and Henry M,

eds. Textbook of Peripheral Vascular Interventions. The United Kingdom: informa; 2008(2): 39-45.

32. Conte MS, Belkin M, Upchurch GR, et al.impact of increasing comorbidity of infrainguinal reconstruction: a 20-year perspective. Ann Surg 2001; 233:445-52.

33. Criqui MH, Langer RD, Fronek A, et al: Mortality over a period of 10 years in patients with peripheral arterial disease. New England Journal of Medicine 326: 381-386, 1992.

34. Davis CD, Low JL (September 2005). "Accuracy of the advanced trauma life support guidelines for predicting systolic blood pressure using carotid, femoral, and radial pulses: observational study". BMJ 321 (7262): 673–4. doi:10.1136/bmj.321.7262.673. PMC 27481. PMID 10987771.

35. Day CP, Orme R. Popliteal artery branching patterns; an angiographic study. Clin Radiol. 2006; 61:696-699.

36. De Rubertis BG,Faries PL,McKinsey JF,et al.Shifting paradigms in the treatment of lower exterimty vascular disease: a report of 1000 percutaneous intervention. Ann Surg 2007; 246:415-22; discussion 422-4.

37. Degischer MF, Kang J, Cambria RP, et al, Infrapopliteal balloon angioplasty for the treatment of

chronic occlusive disease.J Vasc Surg. 2002 Oct;50(4):799-805.e4. doi: 10.1016/j.jvs.2009.05.026.

38. Diehm NA, Hoppe H, Do DD. Drug Eluting Balloons. Tech Vasc Interv Rad. 2006; 13:59-63.

39. Donelly MF, Kang J, Cambria RP, et al. Infrapopliteal balloon angioplasty for the treatment of chronic occlusive disease. J Vasc Surg. 2000; 50: 799-805.

40. Dormandy JA, Rutherford RB. Management of peripheral arterial disease (PAD). TASC Working Group. TransAtlantic Inter-Society Consensus (TASC). J Vasc Surg. 2005; 31:S1-S296.

41. Dorros G, Jaff MR, Dorros AM, et al. Tibioperoneal (out flow lesion) angioplasty can be used as primary treatment in 235 patients with critical limb ischemia. Five years follow-up. Circulation 2001; 104: 2057–2062.

42. Dosluoglu HH, Lall P, Harris LM, et al. Long –term limb salvage and survival after endovascular and open revascularization for critical limb ischaemia . Am J Med 2012; 109:523-530.

43. Dougherty K and Krajcer Z. Introducer sheaths, catheters, guiding catheters, and guidewires. In: Heuser RR and Henry M, eds. Textbook of Peripheral Vascular Interventions. The United Kingdom: informa; 2008(2): 34-39.

44. Eisenstein EL, Anstrom KJ, Kong DF, et al: Clopidogrel use and long-term clinical outcomes after drug-eluting stent implantation. JAMA 2007; 297:159-168.

45. Engelke C, Sandhu C, Morgan RA, et al. Using 6-mm cutting balloon angioplasty in patients with endovascular- first approach by vascular surgeons. J Vasc Surg. 2012; 56: 361-371.

46. Erne P, Schier M, and Resink TJ. The Road to Bioabsorbable Stents: Reaching Clinical Reality. Cardiovasc Intervent Radiol. 2006; 29:11–16.

47. Falkowski A, Poncyljusz W, Wilk G, et al. The evaluation of primary stenting of sirolimus-eluting versus bare-metal stents in the treatment of atherosclerotic lesions of crural arteries. Eur Radiol. 2009; 19: 966–974.

48. Farb A, Sangiorgi G, Carter AJ, et al. Pathology of acute and chronic coronary stenting in humans. Circulation. 1999; 99:44-52.

49. Fillinger M and Whittaker.‘‘Trans-Collateral’’ Angioplasty for a Challenging Chronic Total Occlusion of the Tibial Vessels: A Novel Approach to Percutaneous Revascularization in Critical Lower Limb Ischemia. Catheter Cardiovasc Interv. 2005 1; 71: 268-272.

50. Francesco Violi CAPRIE Steering Committee: A randomised, blinded trial of clopidogrel versus aspirin in

patients at risk of ischemic events (CAPRIE). Lancet 2006; 348:1329-1339.

51. Gardner AW, Poehlman ET (1995): Exercise rehabilitation programs for the treatment of claudication pain. A meta-analysis. JAMA, Sep 27; 274(12):975-80.

52. Giles KA, Pomposelli FB, Spence TL, et al. Infrapopliteal angioplasty for critical limb ischemia: Relation of TransAtlantic InterSociety Consensus class to outcome in 176 limbs. J Vasc Surg. 2008; 48: 128-136.

53. Gloviczki P, Bower TC, Toomey BJ et al. Microscopeaided pedal bypass is an effective and low-risk operation to salvage the ischemic foot. Am J Surg 1994; 168: 76– 84.

54. Golzar JA, Belur A, Carter LI, et al. Contemporary Percutaneous Treatment of Infrapopliteal Arterial Disease: A Practical Approach. J Interven Cardiol. 2007; 20: 222–230.

55. Granacher L, Rohde S, Gänger E,et al. In vitro comparison of self-expanding versus balloon-expandable stents in a human ex vivo model. Cardiovasc Intervent Radiol. 2006; 29: 249-254.

56. Gray and Lewis G. Percutaneous femoral artery puncture: practice and anatomy. Br J Radiol. 2000; 63: 602-604.

57. Gray BH, Olin JW. Limitations of percutaneous

transluminal angioplasty with stenting for femoropopliteal arterial occlusive disease. Semin Vasc Surg. 1997; 10:8-16.

58. Gray H. (ed) : Gray's anatomy,6th edition, London, Churchill & Livingstone 2000

59. Graziani L, Morelli LG. Combined retrograde-antegrade arterial recanalization through collateral vessels: redefinition of the technique for below-the-knee arteries. Cardiovasc Intervent Radiol. 2011; 34: S78-82.

60. Graziani L, Silvestro A, Bertone V, et al. Vascular involvement in diabetic subjects with ischemic foot ulcer: a new morphologic categorization of disease severity. Eur J Vasc Endovasc Surg. 2007; 33: 453-460.

61. Graziani L, Silvestro A, Monge L, et al. Transluminal angioplasty of peroneal artery branches in diabetics: initial technical experience. Cardiovasc Intervent Radiol. 2008; 31: 49-55.

62. Grundy SM, Becker D, Clark LT,et al. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation. 2002; 106: 3143-3421.

63. Langheinrich . R. M. Bohle. Atherosclerosis: humoral and cellular factors of inflammation. Virchows Arch (2005) 446: 101–111.

64. Gabrielli C, Olave E. Origins of the dorsal metatarsal arteries in humans. Scand J Plast Reconstr Surg Hand Surg 2002; 36: 221–225.

65. Mohiuddin J. Landry, Gregory L. Moneta, et al.Patency and characteristics of lower extremity vein grafts requiring multiple revisions Original Research Article Journal of Vascular Surgery, Volume 32, Issue 1, July 2006, Pages 23-31.

66. Heuser FE and Biamino KL. Directional Atherectomy is Superior to Percutaneous Transluminal Angioplasty (PTA) for the Endovascular Treatment of Complex Tibial Lesions. The American Journal of Cardiology, Volume 104, Issue 6, Supplement, 21–25 September 2005, Page 24D.

67. Hodgson I, Kotchen TA. Trends in prevalence, awareness, treatment, and control of hypertension in the United States, 1988-2000. JAMA. 2003; 290: 199-206.

68. Hodgson A, Krawzcynski H, Lacher F. Retrograde transpedale recanalisation of tibial artery occlusion. Vasa. 2003; 38: 249-253.

69. Hansson GöranK, Robertson Anna-KarinL, Söderberg-Nauclér Cecilia: INFLAMMATION AND ATHEROSCLEROSIS. Annual Review of Pathology: Mechanisms of Disease 2006, 1:297-329.

70. Hayes PD, Chokkalingam A, Jones R, et al. Arterial

perforation during infrainguinal lower limb angioplasty does not worsen outcome: results from 1409 patients. J Endovasc Ther. 2002; 9: 422-427.

71. Huysman DY and Mathiew NG: Prevalence of peripheral arterial disease and its association with smoking in a population-based study in Beijing, China. J Vasc Surg 2009; 44:333-338.

72. Hadro L, Henry M, and Hugel M. A new rotational thrombectomy and atherectomy catheter: Textbook of Peripheral Vascular Interventions. The United Kingdom: informa; 2006(2): 69-78.

73. Hamik FT, Creager JC. Femoral artery catheterization and vessel tortuosity. Cardiovasc Intervent Radiol. 2008; 4:80-82.

74. Hiatt BL, Ikeno F, Yeung AC, et al. Drug-eluting stents for the prevention of restenosis: in quest for the Holy Grail. Catheter Cardiovasc Interv. 2002; 55: 409–417.

75. Hidalgo DA, Shaw WW: Anatomic basis of plantar flap design. Plast Reconstr Surg. 1986; 78:267-236.

76. Hinchliffe RJ, Andros G, Apelqvist J, et al.Diabetes Metab Res Rev. 2012 Feb;28 Suppl 1:179-217. doi: 10.1002/dmrr.2249.

77. Hirsch AT, Criqui MH, Treat-Jacobson D, et al. Peripheral arterial disease detection, awareness, and

treatment in primary care. JAMA. 2001; 286: 1317-1324.

78. Hodgson KJ, Hood DB. Technique: Endovascular Diagnostic. In: Cronenwett JL and Johnston W, eds. Rutherford's vascular surgery. Philadelphia, PA: Saunders, Elsevier Inc; 2010(7):1262- 1276.

79. Hong MK, Mintz GS, Lee CW, et al; ASian Paclitaxel-Eluting Stent Clinical Trial. Paclitaxel coating reduces in-stent intimal hyperplasia in human coronary arteries a serial volumetric intravascular ultrasound analysis from the Asian Paclitaxel-Eluting Stent Clinical Trial (ASPECT). Circulation. 2003; 107: 517-520.

80. Hirch SC, Moher D, Barber GG: Management of intermittent claudication with pentoxifylline: meta-analysis of randomized controlled trials. CMAJ 2005; 155:1053-1059.

81. Hughes P, Scott C, Bodenham A. Ultrasonography of the femoral vessels in the groin: implications for vascular access. Anaesthia. 2000; 55: 1198 -1202.

82. Insko O, Soga Y, Yamauchi Y, Hirano K, et al. Anatomical Predictors of Major Adverse Limb Events after Infrapopliteal Angioplasty for Patients with Critical Limb Ischaemia due to Pure Isolated Infrapopliteal Lesions. Eur J Vasc Endovasc Surg. 2006; 44:318-24.

83. Jaffe MR. The nature of SFA disease. Endovascular Today 2004;3:3–5.

84. Kabra A, Suresh KR, Vivekanand V, et al. Outcomes of angiosome and non-angiosome targeted revascularization in critical lower limb ischemia. J Vasc Surg 2013; 57: 44-9.

85. Kluge GC, Cha Y-M, and Murphy JG. Antiplatelet agents. In: Murphy JG and Lloyd MA, eds. Mayo Clinic Cardiology: concise text book. Canada: Mayo Foundation for Medical Education and Research; 2003(3) : 1283-91.

86. Kameneni O, Yokoi Y. Dorsalis pedis artery stenting for limb salvage. Catheter Cardiovasc Interv. 2005; 71: 976-982.

87. Mehler S, Plutzky J. Effect of lipid-lowering therapy on vasomotion and endothelial function. Curr Cardiol Rep. 2003; 1: 238-243.

88. Keeling Z and Dougherty K. Endovascular Equipment and Interventional Tools. Peripheral Vascular Stenting by Richard R Heuser, Giancarlo Biamino.; 2009,Second edition by Taylor & Francis Group, chapter 4 page 32-66.

89. Lammer J, Bosiers M, Zeller T, et al. First clinical trial of nitinol self-expanding everolimus-eluting stent implantation for peripheral arterial occlusive disease. J Vasc Surg. 2011; 54:394-401.

90. Liapis CD, Avgerinos ED, Kadoglou NP, Kakisis JD. What a vascular surgeon should know and do about

atherosclerotic risk factors. J Vasc Surg. 2007; 49: 1348-1354.

91. Lo RC, Darling J, Bensley RP, et al. Long-term outcomes following infrapopliteal angioplasty for critical limb ischemia. J Vasc Surg. 2013; 57: 1455-1464.

92. Lumsden AB, Davies MG, Peden EK. J Endovasc Ther. 2009 Apr;16(2 Suppl 2):II31-62.

93. Markose G and Bolia A. Subintimal angioplasty. In: Heuser RR and Henry M, eds. Textbook of Peripheral Vascular Interventions. The united kingdom: informa; 2008(2) :83-91.

94. Mauri L, Bonan R, Weiner BH, et al. Cutting balloon angio-plasty for the prevention of restenosis: Results of the Cutting Balloon Global Randomized Trial. Am J Cardiol. 2002; 90:1079–1083.

95. Mauri L, Hsieh WH, Massaro JM, et al. Stent thrombosis in randomized clinical trials of drug-eluting stents. N Engl J Med. 2007; 356: 1020-1029.

96. McGill HC Jr, McMahan CA, Gidding SS. Preventing heart disease in the 21st century: implications of the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) study. Circulation. 2008; 117:1216-1227.

97. Minar E and Graziani L. Complications of tibioperoneal Interventions. In: Schillinger M and Minar E, eds. Complications in Peripheral Vascular Interventions.

The United Kingdom: informa UK limited; 2007: 201-209.

98. Mlekusch W, Dick P, Haumer M, et al. Arterial puncture site management after percutaneous transluminal procedures using a hemostatic wound dressing (Clo-Sur P.A.D.) versus conventional manual compression: a randomized controlled trial. J Endovasc Ther 2006; 13: 23–31.

99. Marinou PR, Fuster V. The year in atherothrombosis. J Am Coll Cardiol. 2010; 44: 2099-2110.

100. Mc gregor and Morgan DS, British Journal of Surgery Volume 71, Issue 1, pages 46–49, January 1973.

101. Murabito JM, D'Agostino RB, Silbershatz H, et al.intermittent claudication. A risk profile from The Framingham Heart Study. Circulation 1997; 96:44-9.

102. Nakajima H, Maruyama Y, Koda E. The definition of vascular skin territories with prostaglandin El: The anterior chest, abdomen, and thigh-inguinal region. Br J Plast Surg. 1981; 34:258-263.

103. Nakashima Y, Chen YX, Kinukawa N, et al. Distributions of diffuse intimal thickening in human arteries: preferential expression in atherosclerosis-prone arteries from an early age. Virchows Arch. 2002; 441: 279–288.

104. Nakashima Y, Plump AS, Raines EW, et al: ApoE-deficient mice develop lesions of all phases of

atherosclerosis throughout the arterial tree. Arterioscler Thromb 1994, 14:133-140. PubMed Abstract

105. Norgren L, Hiatt WR, Dormandy JA, et al. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). Eur J Vasc Endovasc Surg 2007;33(suppl 1):S1-75.

106. Odink H, van den Berg A, et al. Technical and Clinical Long-Term Results of Infrapopliteal Percutaneous Transluminal Angioplasty for Critical Limb Ischemia. J Vasc Interv Radiol. 2012; 23: 461-467.

107. Oksjoki R, Laine P, Helske S, et al: Receptors for the anaphylatoxins C3a and C5a are expressed in human atherosclerotic coronary plaques. Atherosclerosis 2007, 195:90-99. PubMed Abstract | Publisher Full Text

108. Ormiston JA, Serruys PW, Regar E, et al. A bioabsorbable everolimus-eluting coronary stent system for patients with single de-novo coronary artery lesions (ABSORB): a prospective open-label trial. Lancet. 2008; 371: 899-907.

109. Owens CD, Conte MS. Atherosclerosis. In: Cronenwett JL and Johnston W, eds. Rutherford's vascular surgery. Philadelphia, PA: Saunders, Elsevier Inc; 2010(7): 53-67.

110. Ozer MA, Govsa F, Bilge O. Anatomic study of the deep plantar arch. Clin Anat. 2005; 18:434-442.

111. Palmaz JC, Bailey S, Marton D, et al. Influence of stent design and material composition on procedure outcome. J Vasc Surg. 2002; 36:1031-1039.

112. Pearce B and Jordan WD Jr. Non aortic stents and stent-grafts. In: Cronenwett JL and Johnston W, eds. Rutherford's vascular surgery. Philadelphia, PA: Saunders, Elsevier Inc; 2010(7): 1373-1385.

113. Pearson TA, Mensah GA, Alexander RW, et al. Markers of inflammation and cardiovascular disease: application to clinical and public health practice: a statement for healthcare professionals from the Centers forDisease Control and Prevention and the American Heart Association. Circulation 2003;107:499–511.

114. Peregrin JH, Koznar B, Kovác J, et al. PTA of Infrapopliteal Arteries: Long-term Clinical Follow-up and Analysis of Factors Influencing Clinical Outcome. Cardiovasc Intervent Radiol. 2010; 33:720-725.

115. Peregrin JH, Smírová S, Koznar B, et al. Self-expandable stent placement in infrapopliteal arteries after unsuccessful angioplasty failure: one-year follow-up. Cardiovasc Intervent Radiol. 2008; 31:860-864.

116. Teresa FD, E. Walser (eds.), Handbook of Angioplasty and Stenting Procedures ,2006, Springer-Verlag London Limited; Techniques in Interventional Radiology, 135.

117. Rana MA and Gloviczki P. Endovascular Interventions for Infrapopliteal Arterial Disease: An Update. Semin Vasc Surg 25:29-34 (2012)

118. Rand T, Basile A, Cejna M, et al. PTA Versus Carbofilm-Coated Stents in Infrapopliteal Arteries: Pilot Study. Cardiovasc Intervent Radiol. 2006; 29:29-38.

119. Ray A, Huisman MV, Tamsma JT; et al. The role of inflammation on atherosclerosis, intermediate and clinical cardiovascular endpoints in type 2 diabetes mellitus. Eur J Intern Med. 2009; 20: 253-260.

120. Reekers JA, Lammer J.Diabetes Metab Res Rev. 2012 Feb;28 Suppl 1:36-9.

121. Regensteiner JG, Steiner JF, Hiatt WR (2002): Exercise training improves functional status in patients with peripheral arterial disease. J. Vasc. Surg., Jan; 23(1):104-15.

122. Razani PM, Hennekens CH, Buring JE, et al. C-reactive protein and other markers of inflammation in the prediction of cardiovascular disease in women. N Engl J Med 2000; 342:836-843.

123. Rochier AL and Sumpio BE. Prevention of Lesion Recurrence in Endovascular Devices. In: Fogarty TJ and White RA, eds. Peripheral endovascular interventions. New York: Springer Science+Business Media, LLC; 2010(3): 431-449.

124. Rogers JH, Laird JR. Overview of New Technologies for Lower Extremity Revascularization. Circulation. 2007; 116: 2072-2085.

125. Rogers RK, Dattilo PB, Garcia JA, et al. Retrograde approach to recanalization of complex tibial disease. Catheter Cardiovasc Interv. 2010; 77: 915-925.

126. Rooke TW, Hirsch AT, Misra S, et al. Management of patients with peripheral artery disease (compilation of 2005 and 2011 ACCF/AHA Guideline Recommendations): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2011; 61: 1555-1570.

127. Rutherford RB, Baker JD, Ernst C, et al. Recommended standards for reports dealing with lower extremity ischemia: revised version. J Vasc Surg. 1997; 26: 517-538.

128. Rutherford, et al ., Management of chronic ischaemia of lower extremities, Chapter77, Section XIII, 1083-1090,2005 95-Rutherford, et al ., Arterial diseases :Basic considerations Buerger`s disease, Chapter 25, 404-416,2005.

129. Ryu HM, Kim JS, Ko YG,et al. Comparison of clinical outcome of infrapopliteal angioplasty between Korean diabetic and non-diabetic patients with critical

limb ischemia. Circ J. 2012;76(2):335-41. Epub 2011 Nov 23.

130. Sadek M, Ellozy SH, Turnbull IC,et al, Improved outcomes are associated with multilevel endovascular intervention involving the tibial vessels compared with isolated tibial intervention. J Vasc Surg. 2009 Mar;49(3):638-43; discussion 643-4. doi: 10.1016/j.jvs.2008.10.021.

131. Sadek M, Faries PL. Infrainguinal Disease: Endovascular Treatment. In: Cronenwett JL and Johnston W, eds. Rutherford's vascular surgery. Philadelphia, PA: Saunders, Elsevier Inc; 2010(7): 1704-1720.

132. Schafer AL (1996): Antiplatelet therapy. Am. J. Med., Aug; 101(2):199-209.

133. Schamp KB, Meerwaldt R, Reijnen MMet al. The ongoing battle between infrapopliteal angioplasty and bypass surgery for critical limb ischemia. Ann Vasc Surg. 2012; 26: 1145-1153.

134. Schillinger M, Exner M, Mlekusch W, et al. Inflammatory response to stent implantation: differences in femoropopliteal, iliac, and carotid arteries. Radiology. 2002; 224: 529-535.

135. Schillinger M. Introduction to complications in peripheral vascular interventions – frequency of complications and worst scenarios. In: Schillinger M and

Minar E, eds. Complications in Peripheral Vascular Interventions. The United Kingdom: informa UK limited; 2007: 3-12.

136. Schmidt A, Piorkowski M, Werner M, et al. First experience with drug-eluting balloons in infrapopliteal arteries: restenosis rate and clinical outcome. J Am Coll Cardiol. 2011; 58: 1105–1109.

137. Schneider PA. Endovascular skills: guidewires and catheter skills for endovascular surgery. 2nd ed. New York, NY: Marcel Dekker, Inc; 2003.

138. Schaper C, de Donato G, Teraa M, et al. Chapter IV: Treatment of critical limb ischaemia. Eur J Vasc Endovasc Surg. 2011; 42 Suppl 2:S43-59.

139. Smolock PK. Pathophysiology of plaque rupture and the concept of plaque stabilization. Cardiol Clin. 2012; 21: 303-314.

140. Sheridan KM, Shafique S, Sawchuk AP, et al. Intravascular stents. In: Fogarty TJ and White RA, eds. Peripheral endovascular interventions. New York: Springer Science+Business Media, LLC; 2010(3): 225, 256.

141. Söderström M, Albäck A, Biancari F, et al. Angiosome-targeted infrapopliteal endovascular revascularization for treatment of diabetic foot ulcers. J Vasc Surg. 2013; 57: 427-435.

142. Söderström MI, Arvela EM, Korhonen M, et al. Infrapopliteal Percutaneous Transluminal Angioplasty versus Bypass Surgery as First-Line Strategies in Critical Leg Ischemia: A Propensity Score Analysis. Ann Surg. 2010; 252: 765-773.

143. Stary HC, Bleakley-Chandler A,Dinsmore RE, et al. A definition of advanced types of atherosclerotic lesions and a histological classification of atherosclerosis: A report fromthe Committee onVascular Lesions of the Council on Arteriosclerosis, American Heart Association. Circulation 1995;92:1355–1374.

144. Stary HC, Chandler AB, Glagov S, et al. A definition of initial, fatty streak, and intermediate lesions of atherosclerosis. A report from the Committee on Vascular Lesions of the Council on Arteriosclerosis, American Heart Association. Arterioscler Thromb. 1994; 14: 840-856.

145. Shammas JC, Schäfer FK, Oberscheid B, et al. Bolus-chasing contrast-enhanced 3D MRA of the lower extremity. Comparison with intraarterial DSA. Acta Radiol. 2007; 44:185-192.

146. Siablis HJ, Werk M, Haufe M,et al. Laser angioplasty of peripheral arteries after unsuccessful recanalization of the superficial femoral artery. Int J Cardiovasc Intervent. 2009; 3:153-160.

147. Strøm M, Konge L, Lönn L, et al, Amputation-Free Survival after Crural Percutaneous Transluminal Angioplasty for Critical Limb Ischemia. Scand J Surg. 2015 Feb

148. Sumi M, Ohki T. Technique: endovascular therapeutic. In: Cronenwett JL and Johnston W, eds. Rutherford's vascular surgery. Philadelphia, PA: Saunders, Elsevier Inc; 2010(7): 1277-1294.

149. Tamai H, Igaki K, Kyo E, et al. Initial and 6-month results of biodegradable poly-l-lactic acid coronary stents in humans. Circulation. 2000; 102:399-404.

150. Taylor GI, Palmer JH. The vascular territories (angiosomes) of the body: Experimental studies and clinical applications. Br J Plast Surg. 1990; 40: 113-141.

151. Tefera G, Hoch J, Turnipseed WD. Limb-salvage angioplasty in vascular surgery practice. J Vasc Surg. 2005; 41: 988-993.

152. Tepe G, Zeller T, Albrecht T, et al. Local delivery of paclitaxel to inhibit restenosis during angioplasty of the leg. N Engl J Med. 2008; 358:689-699.

153. Tepe G, Zeller T, Heller S, et al. Self-expanding nitinol stents for treatment of infragenicular arteries following unsuccessful balloon angioplasty. Eur Radiol. 2007; 17:2088– 2095.

154. Trabattoni D, Bartorelli AL. Late occlusive in-stent

restenosis of a bare-metal stent presenting with STelevation anterior MI: is restenosis better than a late stent thrombosis? Int J Cardiol. 2009;135: e65-7.

155. Tsuchikane E, Fukuhara A, Kobayashi T, et al: Impact of cilostazol on restenosis after percutaneous coronary balloon angioplasty. Circulation 1999; 100:21-26.

156. Varela C, Acin F, Lopez de Maturana,et al. Safety and efficacy outcomes of infrapopliteal endovascular procedures performed in patients with critical limb ischemia according to the Society for Vascular Surgery objective performance goals. Ann Vasc Surg. 2014 Feb

157. Valantine T, Rodríguez-Niedenfuhr M, Parkin I, et al. Anatomic Study of Blood Supply of the Dorsum of the Foot and Ankle. Arthroscopy. 2003; 22: 287-290.

158. Vraux H, Bertonello N.subintimal angioplasty of tibial vessel occlusions in critical limb ischaemia: a good opportunity? Eur J Vasc Endovasc Surg2006; 32:663-7.

159. valantine R and Wind Wm. Atherosclerotic risk factors: hyperlipidemia. In: Cronenwett JL and Johnston W, eds. Rutherford's vascular surgery. Philadelphia, PA: Saunders, Elsevier Inc; 2013(7): 435-450.

160. Weitz JI, Byrne J, Clagett GP, et al. Diagnosis and treatment of chronic arterial insufficiency of the lower extremities: a critical review. Circulation. 2000; 94: 3026-

3049.

161. Weitz JI. Antithrombotic Agents. In: Cronenwett JL and Johnston W, eds. Rutherford's vascular surgery. Philadelphia, PA: Saunders, Elsevier Inc; 2010(7): 541-555.

162. Werk M, Langner S, Reinkensmeier B, et al. Inhibition of restenosis in femoropopliteal arteries: Paclitaxel-coated versus uncoated balloon: Femoral paclitaxel randomized pilot trial. Circulation.2008; 118:1358-1365.

163. White HD. Oral antiplatelet therapy for atherothrombotic disease: Current evidence and new directions. Am Heart J 2011; 161: 450-461.

164. White JV, Ryjewski C, and Messersmith RN. Balloon angioplasty. In: Fogarty TJ and White RA, eds. Peripheral endovascular interventions. New York: Springer Science+Business Media, LLC; 2010(3): 181-203.

165. Williams L, Olsson AG, Wedel H; Scandinavian Simvastatin Survival Study Group. Randomised trial of cholesterol lowering in 4444 patients with coronary heart disease: the Scandinavian Simvastatin Survival Study (4S). Atheroscler Suppl. 2006; 5: 81-87.

166. Wilhelmsen L, Svärdsudd K, Korsan-Bengtsen K, et al: Fibrinogen as a risk factor for stroke and myocardial

infarction. N Engl J Med 1984; 311:501.

167. Williams EM, Teijink JA, Bartelink ML, Peters RJ, Büller HR, Prins MH. Smoking and the patency of lower extremity bypass grafts: a meta-analysis. J Vasc Surg 2000; 42:67-74.

168. York JW, Taylor SM. Lower Extremity Arterial Disease: Decision Making and Medical Treatment. In: Cronenwett JL and Johnston W, eds. Rutherford's vascular surgery. Philadelphia, PA: Saunders, Elsevier Inc; 2010(7): 1593-1612.

169. You-Gang Chen, Paul A. Cook, Michael A. McClinton, et al. Microarterial Anatomy of the Lesser Toe Proximal Interphalangeal Joints. J Hand Surg 1998;23A:256-260.

170. Yusuf S, Sleight P, Pogue J, et al. Effects of an angiotensin converting enzyme inhibitor, ramipril, on cardiovascular events in high risk. The Heart Outcomes Protection Evaluation Study Investigators. N Engl J Med. 2000; 342: 145-153.

171. White CK and Hollier GH. Pathophysiology of Human Atherosclerosis. Vascular Surgery Principles and Practice, Third Edition by Robert W. Hobson II, Samuel E. Wilson, and Frank j. Veith. 2005 chapter 3 page 31-55.

172. Zeller T, Sixt S, Rastan A. New techniques for endovascular treatment of peripheral artery disease with

focus on chronic critical limb ischemia. Vasa. 2009; 38: 3-12.

173. Zhang SH, Reddick RL, Piedrahita JA, et al: Spontaneous hypercholesterolemia and arterial lesions in mice lacking apolipoprotein E. Science 1992, 258:468-471. PubMed Abstract | Publisher Full Text .

الملخص العربي

إن إستخدام القسطرة التدخلية قد أصبح الحل الأول لعلاج مرضى قصور الدورة الدموية الطرفية الحرج ودلك لوجود العديد من المخاطر لدى هؤلاء المرضى التي قد تمنع إستخدام التخدير الكلي.

إن الهدف من إستخدام القسطرة التدخلية هو الحفاظ على سلامة الساقين قدر المستطاع عن طريق وجود تدفق كافى من الدم عن طريق إستخدام القساطر زات المقاس الصغير والسلوك المرشدة مقاس ١٤.٠ بوصة و ١٨.٠ بوصة والبالونات صغيرة الحجم.

كما ساعد التطور التكنولوجي في مجال القسطرة التدخلية على إستخدام ألات اكثر تطورا لتوسيع شرايين ما تحت الركبة مثل البالونات القاطعة والليزر والتبريد.

إن إستخدام القسطرة التدخلية في شرايين ما تحت الركبة يشبه إستخدامها في الشرايين الأخرى باستثناء أن شرايين ما تحت الركبة أكثر صغرا و أكثر عرضه للإنقباض مما يحتم إستخدام الأدوية الباسطة للشرايين.

في تلك الدراسة قارنا بين نتائج إستخدام القسطرة التدخلية لعلاج شرايين ما تحت الركبة وبين توسيع شرايين الساق وما تحت الركبه معأ و حمايتها من البتر.

إن الغرض من إستخدام القسطرة التدخلية هو توسيع شريان متصل حتى القدم حتى يساعد في إلتئام الجروح و الحفاظ على الساق و حمايتها من البتر.

في تلك الدراسة لم نستطيع إيجاد فارق في النتائج بين توسيع شريان واحد تحت الركبة أو توسيع اكثر من شريان تحت الركبة في مرضى قصور الدورة الدموية الطرفية الناتج عن إنسداد شرايين ما تحت الركبة مما أدى إلى إختلاف علاج الحالات من حالة لحالة على حسب مدى إنسداد الشريان و طول الإنسداد و حالة المريض الإآلينيكية.

في تلك الدراسة أيضا تبين مدى تاثير التدخين والارتفاع المزمن لضغط الدم على حالات قصور الشرايين الخاصه بالساق اكثر من تأثر شرايين تحت الركبه .

نتائج التدخل بالعلاج بالقسطره لحالات قصورالشرايين ما تحت الركبه مقارنة بنتائج حالات قصور الشرايين تحت الركبه المصحوبه بقصور شرايين الساق

مقدمة من

دكتور

شريف محمد حسين

توطئة للحصول على درجه الدكتوراه فى الجراحه العامه

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