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RESEARCH ARTICLE

A STUDY TO DETERMINE THE SHORT TERM OUTCOME OF INFRAINGUINAL BYPASS FOR CRITICAL LIMB ISCHEMIA

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Abstract

Introduction: Critical limb ischemia is defined as persistent, recurring ischemic rest pain requiring opiate analgesia for at least 2 weeks, or ulceration or gangrene of the foot or toes and ankle systolic pressure lower than 50 mm Hg or toe systolic pressure lower than 30 mm Hg. CLI is a clinical diagnosis and it should be confirmed early and objectively through ABI, toe systolic pressure or transcutaneous partial pressure of oxygen (TcPO2). Once the diagnosis is confirmed, the goals of treating CLI are to relieve ischemic pain, heal ischemic ulcers, prevent limb loss, improve patient function and QOL and prolong survival. Revascularization will help to achieve these goals. The aim of the study is to assess the outcome of infra-inguinal bypass surgery in all PVD patients who presented to our General Surgery department with CLI.

Objectives: To assess the following in CLI after infra-inguinal bypass surgery: 1) Wound healing 2) Limb salvage 3) Self assessed degree of ambulation 4) Primary patency of graft-using arterial doppler

Methods: This is a single directional cohort study conducted in 48 patients who presented to Amala General Surgery Department with critical limb ischemia, who underwent infra-inguinal bypass surgery with reversed saphenous vein graft. PVD patients with CLI were assessed preoperatively. Periodic assessment was also done during postoperative period at 1 month and 6 months. Primary graft patency was checked at 6 months using arterial doppler. These patients were monitored closely during the pre-operative period, during surgery and postoperative period. They were also followed up at 1 and 6 months. The study duration is 18 months, from January 2018 to June 2019.

Results and Discussion: From January 2018 to June 2019, 48 patients (37 males, mean age of 65 years) underwent infrainguinal bypasses (37 femoropopliteal, 11 femorodistal) for CLI (12 Fontaine III and 36

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Fontaine IV).There was no perioperative mortality. The mean duration of hospitalization was 10.542 with standard deviation of 3.2809.Wound healing observed at 1 month is 39.58%, which was increased to 77.08 % at the end of 6 months (Mc Nemar Test p value=0.0001).Limb salvage attained at the end of 6 months is 87.5%.Ambulatory status of the patients were assessed at the end of 1 month after surgery and only 2% were ambulatory outdoors, 90 % were ambulating indoors and 8% were non-ambulatory. Total ambulatory status post-surgery (indoor and outdoor combined), came around 92% at 1 month. At 6 months post-surgery, 19 % of patients were ambulating outdoors, 60 % were ambulating indoors and 21 % were non-ambulatory. Total ambulatory status at 6 months (indoor and outdoor combined) post-surgery came around 79 % (Mc Nemar Test p value = 0.001) and primary patency of the graft at 6 months for our cohort is 79.2%.

Conclusion: This Study includes 48 patients with CLI who has undergone infrainginal bypass with reversed saphenous vein graft. 87.5% limb salvage, 77.08% wound healing at 6 months, 79% was ambulatory status at 6 months and 79.2% primary graft patency were attained.. 7 out of 8 CLI patients treated surgically has limb salvage and good functional status.

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Introduction:-

Critical Limb Ischemia (1)

Critical limb ischemia (CLI) is a clinical syndrome characterized by ischemic pain at rest and tissue loss such as non-healing ulcers or gangrene related to objectively proven peripheral artery disease (PAD) of the lower limbs (2).

It is different from acute limb ischemia, where there is sudden loss of limb perfusion (defined as within 14 days) typically caused by an embolus or in situ thrombus (3). CLI occurs over several weeks to months and is at the extreme end of the spectrum of chronic limb ischemia (Table -Rutherford classification 4–6, Fontaine III/IV). Knowledge about CLI and timely diagnosis is important because of the higher risks of limb loss and cardiovascular events than asymptomatic PAD and intermittent claudication. Typically, at 1 year following presentation, 25% of patients have resolved CLI, 20% have ongoing CLI, 30% are alive with amputation and 25% are dead. Thus the poor prognosis demands rapid assessment, with a greater role for wound care and early revascularization.

A multidisciplinary approach involving specialists in endovascular revascularization, open surgical revascularization, podiatry, wound care and other specialties is often required to maximize patient outcomes in CLI. The therapeutic goals in treating CLI patients include reducing cardiovascular risk factors, relieving ischemic pain, healing ulcers, preventing major amputation, improving quality of life and increasing survival. These aims may be achieved through medical therapy, revascularization, or amputation (2).

Critical limb ischemia (CLI) is a limb threatening condition that requires revascularization to relieve ischemic pain, heal ischemic ulcers, prevent limb loss, and preserve ambulatory status and quality of life of the patient. The gold standard for treatment of CLI is surgical bypass with an autogenous vein, with numerous reports documenting graft and limb related outcomes.

Patients with CLI who do not undergo arterial revascularization have mortality and amputation rates as high as 54% and 46% respectively after 12 months and have significant morbidity, with cardiovascular event rates surpassing those in patients with symptomatic coronary artery disease (CAD). In contrast, patients with CLI who undergo successful revascularization survive longer and have an improved quality of life compared to patients who only receive medical treatment or those who undergo primary amputation(3).

Critical limb ischemia occurs after persistent perfusion failure that leads to rest pain or trophic lesions of the legs, or both. Thus, CLI is an end stage of peripheral arterial disease (PAD) where there is an issue of supply vs demand, that is, there is inadequate blood flow to supply vital oxygen demanded by the limb.

The patients with CLI are classified (5) in the severe ends of the Fontaine classification (stage III-IV) or the Rutherford classification (grades 4-6). Studies have shown that progression of the disease from PAD to CLI is variable and unpredictable but regardless of where in the spectrum of PAD these patients fit, CLI patients suffer from the worst form of PAD and high priority should be given for early detection and optimization of surgical and nonsurgical treatments.

Classification	Stage	Clinical description
Fontaine	I	Asymptomatic
	IIa	Mild claudication
	IIb	Moderate-to-severe claudication
	III	Rest pain
	IV	Ulceration or gangrene
Rutherford	0	Asymptomatic
	1	Mild claudication
	2	Moderate claudication
	3	Severe claudication
	4	Rest pain
	5	Minor tissue loss
	6	Severe tissue loss or gangrene

Table No.1:- Classification of Peripheral Arterial Disease (5).

Delayed reference to vascular surgeon leads to increased amputation rates, reduced limb salvage, wound healing and quality of life (6)

The diagnosis of CLI is straightforward and is by vascular examination, ankle-brachial index (ABI) and a number of imaging modalities but how to optimally care for patients with CLI, whether surgically or medically is not as clear (4).

Epidemiology And Natural History (7)

PAD is associated with a threefold to six fold increased risk of cardiovascular morbidity and mortality compared to individuals without PAD. PAD patients are at an exceptionally high risk for cardiovascular events and most eventually die of a cardiac or cerebrovascular event (8). Patients with CLI are also at higher risk for cardiovascular ischemic events than those with PAD alone. Patients with CLI represent approximately 1% of the total number of patients with PAD, with overall mortality in these patients around 50% at 5 years and 70% at 10 years. There is also considerably high immediate post-operative mortality and major limb amputation, with a recent meta-analysis reviewing 31studies involving bypass grafts for CLI showing rates as high as 11.6 % (9). A study in 2009 revealed that amputation rates at 1 year after lower extremity bypass were 12% for patients with CLI as opposed to 1% for patients with claudication (10).

Bertele et al, in 1999, reported a large prospective multicenter cohort consisting of 1586 patients with CLI and observed a 6- month amputation rate of 12% and 1-year mortality rate of 19.1%, demonstrating that the diagnosis of CLI has remained a predictor of poor overall survival and outcomes during the past decade and that these rates have not changed substantially over the years (11). Several observational studies of patients diagnosed with CLI revealed

that at 1 year only 50% of the patients will remain amputation-free although they may still be symptomatic, whereas 25% will require a major amputation and the remaining 25% will have died.

The best data for CLI patients undergoing vein bypass grafting is given by the recent multicenter, randomized trial of Edifoligide for the prevention of vein graft failure in lower extremity bypass surgery (PREVENT III) because it strictly studied CLI patients and included patients with advanced comorbidities or those requiring complex operative procedures(12). The results showed a 2.7% perioperative mortality rate, 5.2% graft occlusion rate, 16% mortality rate ,80% secondary patency rate, and an 88% limb salvage rate at 1 year .

Studies have also shown that the economic burden for treatment of CLI is also considerably high. Brahmanandam et al reported that CLI patients who underwent revascularization used more health care services after hospital discharge than non-CLI patients. These services included home health care and transfers to rehabilitation facilities. The average cost of managing a patient after amputation is estimated at almost twice that of successful limb salvage (13).

Thus, CLI represents a challenging disease state that is associated with considerable morbidity and mortality, in addition to a large financial impact on the patient and society.

Pathophysiology Of Critical Limb Ischemia (3)

Healing of ulcers occur normally unless wound repair mechanisms are altered, like diminished arterial perfusion, infection, or repeated trauma. Non-healing wounds occur as the result of arterial insufficiency, neuropathy, musculoskeletal abnormalities, or a combination of these. Decreased perfusion is most commonly due to atherosclerotic occlusive disease of major arterial conduits. Patients with relatively mild symptoms of arterial insufficiency may develop non-healing ulcers if other factors are involved, as the blood supply needed to heal an ulcer is greater than that needed to maintain an intact integument. Another frequent risk factor for foot ulceration is both sensory and autonomic neuropathy. In addition to reducing sensation to pain and thermal stimuli, neuropathy involving motor fibers leads to ataxic gait and weakness of the foot muscles. High stress loads in areas not typically used to weight-bearing, accompanied by loss of protective sensation, leads to increased shear stress, repetitive trauma and skin breakdown.

CLI occurs when arterial lesions impair blood flow to such an extent that the nutritive requirements of the tissues cannot be met. Normally the skin microcirculation is involved in skin tissue nutrition and heat exchange during thermal stress. In patients with CLI, compensatory mechanisms of skin perfusion are compromised and the skin fails to receive adequate nutrition. Inadequate perfusion leads to a host of microcirculatory defects like endothelial dysfunction, altered hemorrheology, inflammation, and loss of sympathetic auto regulatory response to change in posture. Rheological disturbances are present as well, including decreased erythrocyte fluidity, blood viscosity, and erythrocyte volume fraction. The overall effect of these derangements is rest pain, trophic changes and impaired wound healing.

Features Of Critical Limb Ischemia (1)

Physical examination (14)

1. Dry skin, thickened nails, loss of hair, loss of subcutaneous fat or muscle atrophy
2. Cool on palpation
3. Decreased or absent pulses
4. Elevation pallor or dependent rubor
5. Non-healing wound or ulcer, especially over bony prominences, distally and on the plantar surface of the foot

Non-invasive vascular laboratory (15)

1. Ankle–brachial index ≤ 0.3
2. Ankle systolic pressure ≤ 50 mmHg
3. Toe systolic pressure ≤ 30 mmHg
4. Measures of skin microcirculation capillary density ≤ 20 mm2
5. Absent reactive hyperemia on capillary microscopy, TcPO2 < 10 mmHg

Evaluation of CLI (14)

There are a number of tests available to confirm the diagnosis of CLI, to assess foot perfusion, and predict wound healing. The ankle–brachial index (ABI) provides the key prognostic and diagnostic information for patients with CLI. In patients with incompressible lower limb arteries, an ABI > 1.3 represents an independent predictor of major amputation. In patients with a falsely elevated ABI, the toe–brachial index (TBI) or toe pressure may be diagnostic. TcPO2, a non-invasive measure of skin oxygenation, is reduced in the presence of impaired blood flow. However, based upon the results of a recent randomized trial, even where the diagnosis of CLI is uncertain, the addition of toe pressures and TcPO2 does not alter the number of diagnostic studies or therapeutic interventions. Skin microcirculation may be assessed using capillary microscopy, laser Doppler perfusion or transcutaneous oxygen pressure (TcPO2). Nail fold capillary microscopy of the great toe enables visualization of capillary morphology, density and erythrocyte velocity at rest and during reactive hyperemia. Micro vascular dynamics, flow distribution, and micro vascular permeability can be assessed using dyes like sodium fluorescein. Microcirculation is classified as 'good', 'intermediate', or 'poor' according to some cut-off values (poor - capillary density < 20/mm2, absent reactive hyperemia in capillary microscopy and laser Doppler, TcPO2 < 10 mmHg; good - capillary density > 20/mm2 , reactive hyperemia in capillary microscopy and laser Doppler, TcPO2 > 30 mmHg). Limb survival at 1 year (16) was 15% in the poor group, 63% in the intermediate group, and 88% in the good group. Patients who are not candidates for revascularization and who have poor skin microcirculation may be best served by undergoing amputation rather than aggressive local therapy. Laser Doppler perfusion study is used to provide information about flow in capillaries, deeper vessels, and arterio-venular anastomoses that are involved in thermoregulation.

ABPI

ABPI (17) is the key diagnostic and prognostic indicator in patients with CLI. It is calculated by dividing the systolic blood pressure measured in the arterial conduits at the level of the ankle by the systolic blood pressure measured in the brachial artery.

ABPI=Ankle systolic blood pressure /Brachial systolic pressure

ABPI is used to assess patients for peripheral arterial disease as a fall in blood pressure in an artery at the ankle relative to the central blood pressure would suggest a stenosis in the arterial conduits somewhere in between the aorta and the ankle.

Interpretation of ABPI

Resting ABPI	Severity of disease
>1.4	Calcification may be present
>1.0	Probably no arterial disease
0.81–1.00	No significant arterial disease, or mild/insignificant disease
0.5–0.80	Moderate disease
<0.5	Severe disease
<0.3	Critical ischemia

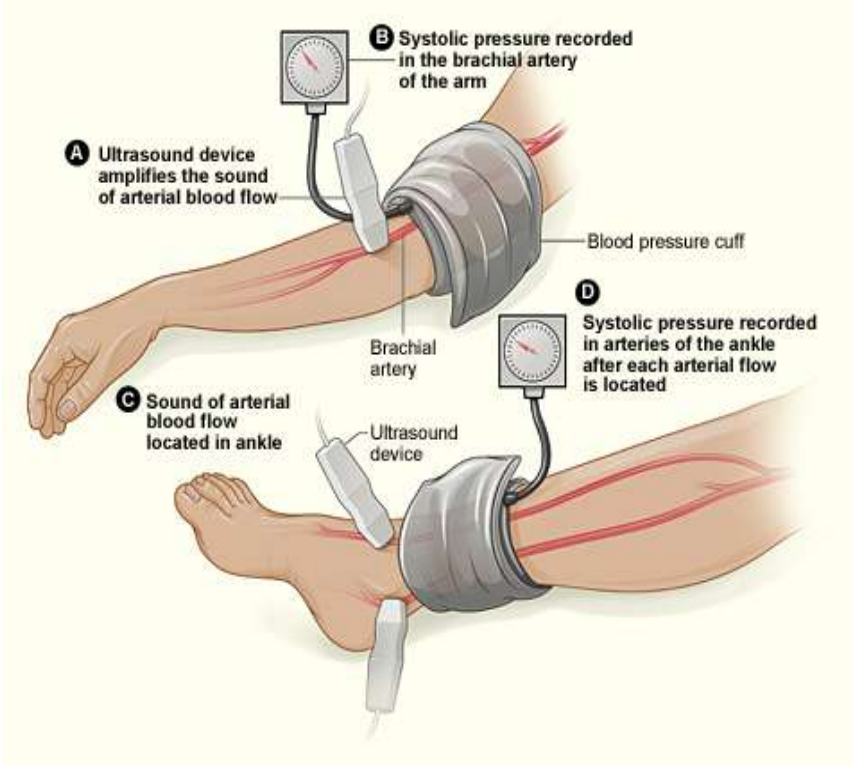

Figure No.1:- Measurement of ABPI (1).

Doppler ultrasonography

Doppler ultrasonography (18) uses the Doppler Effect to image the movement of tissues and body fluids (usually blood), and to assess their relative velocity to the probe. For example, flow in an artery or a jet of blood flow over a heart valve, its speed and direction can be determined and visualized, by calculating the frequency shift of a particular sample volume. Colour Doppler or colour flow Doppler is the representation of the velocity by colour scale. Colour Doppler images are generally combined with grayscale (B Mode) images to display duplex ultrasonography images, allowing for simultaneous visualization of the anatomy of the area.

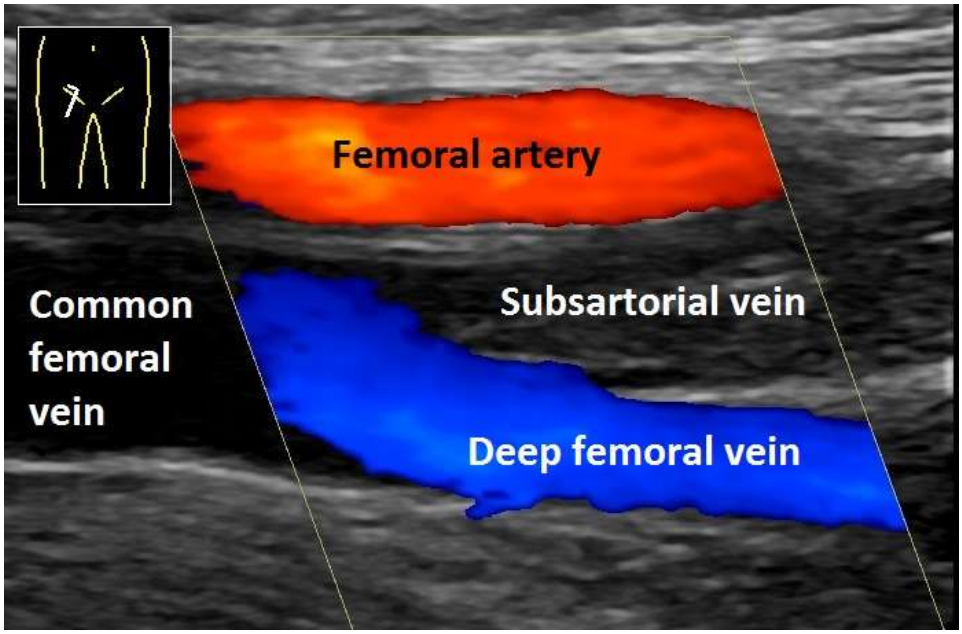

Figure No.2a:- Colour Doppler.

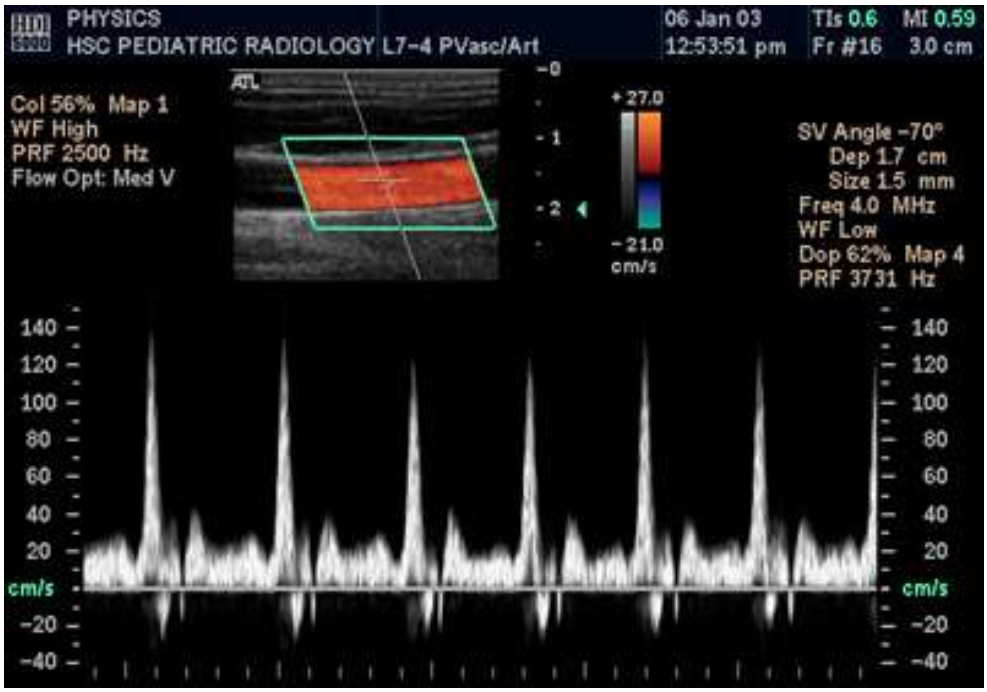

Figure No.2b:- Colour Doppler.

Computed Tomographic Angiography (CTA)

CTA (18) can be used to detect atherosclerosis of the lower limb arteries and also to image vessels in case of suspected blocks, trauma and in patients with surgical complications. In CT angiography, images are taken after injection of a radio dense contrast. The CT scanner uses either automatic detectors that start scanning when adequate contrast is present, or small test boluses. In the small test bolus, a small quantities of contrast is injected to assess the speed of the contrast within the vessels, after which the full bolus is injected. The images are then processed for better visualization and even 3D images can be created.

Figure No.3:- Computed Tomographic Angiogram.

Magnetic Resonance Angiography (MRA)

MRA (18) is a group of techniques based on MRI to image arteries to assess stenosis, occlusions, aneurysms or other abnormalities. Gadolinium contrast enhanced MRA has been reported to have high sensitivity and specificity to detect and assess the degree of stenosis and the extent of the lesion and also to identify the distal target vessels. Disadvantages of MRA include cost, long duration of the study, and discomfort to the patient. Also, it is contraindicated in patients with metallic implants and in those with renal failure or renal insufficiency due to Gadolinium being nephrotoxic.

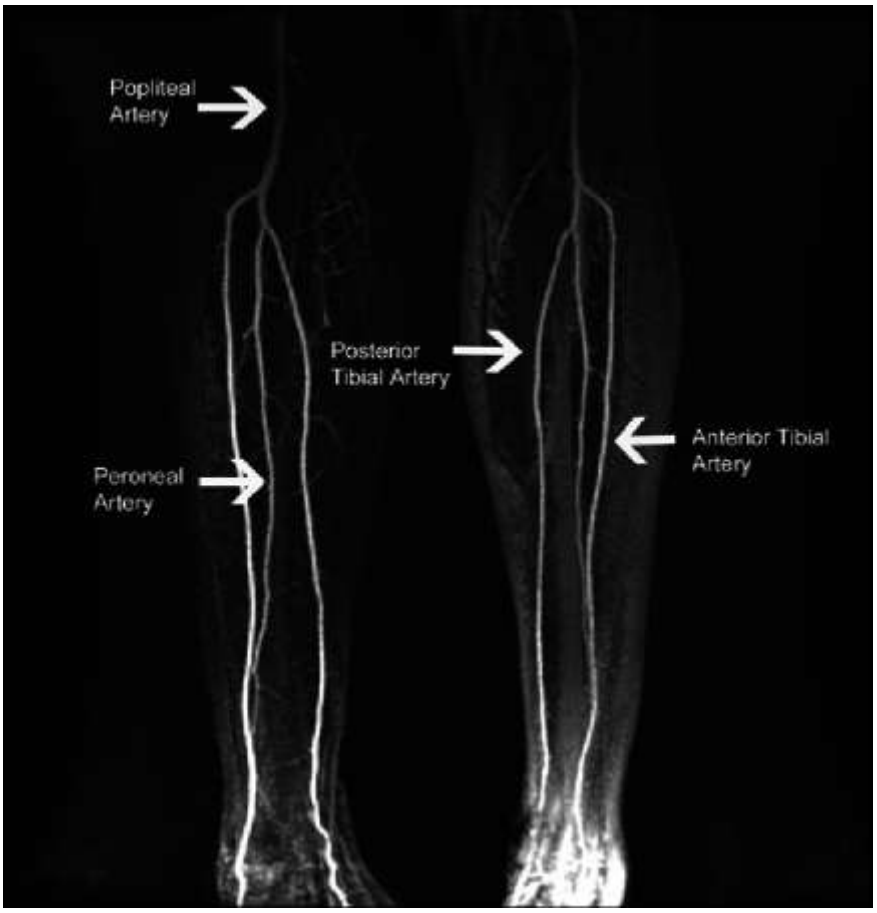

Figure No.4:- Magnetic Resonance Angiography.

Peripheral Angiogram

It is the gold standard imaging technique (19) to delineate the location and the nature of the disease when surgical intervention is planned. It is done only in patients planned for surgery depending on the severity of the disease due to its invasive nature and the risk of complications like groin hematoma, retroperitoneal bleeding, pseudo aneurysm and arterial dissection. These risks can be reduced by using ultrasound guided access and micro puncture methods.

A pelvic angiography is done with a multi-side hole catheter at the aortic bifurcation and images of the bilateral common iliac, hypogastric, external iliac, common femoral, proximal superficial femoral and profunda femoris arteries. The contralateral common femoral artery is then selected using an end hole catheter and the contralateral SFA, profunda femoris, popliteal, tibial and pedal arteries are imaged. The access sheath is then pulled back to the level of the ipsilateral external iliac artery to image the ipsilateral limb. Complete assessment of the aortic and iliac inflow and bilateral lower extremities requires about 75-100 ml of contrast. Renal risks associated with the use of contrast can be reduced by prudent use of contrast, selective catheterization which helps reduce the quantity of contrast required and using contrasts with lower ionic load or isomolar agents. Adequate oral hydration before and after angiography also is useful.

Figure No.5:- Peripheral Angiography.

Carbon Dioxide Angiography (20)

This method with CO2 as contrast is especially useful in patients with chronic renal insufficiency. CO2 works as contrast by temporarily displacing blood in the artery being imaged. Disadvantages of this method include poor detail particularly in the distal vessels, significant patient discomfort due to the CO2 bolus, and CO2 embolus with gas trapping leading to mesenteric ischemia.

Intravascular Ultrasound

Intravascular ultrasound (IVUS) (20) is an imaging methodology using a specially designed catheter with a miniaturized ultrasound probe attached to the distal end of the catheter. The proximal end of the catheter is attached to computerized ultrasound equipment. It allows the application of ultrasound technology, such as piezoelectric transducer or CMUT, to see from inside blood vessels out through the surrounding blood column, visualizing the endothelium (inner wall) of blood vessels in living individuals. With improvements in high-frequency smaller transducers, the use of catheter-based intravascular ultrasound IVUS can be done.

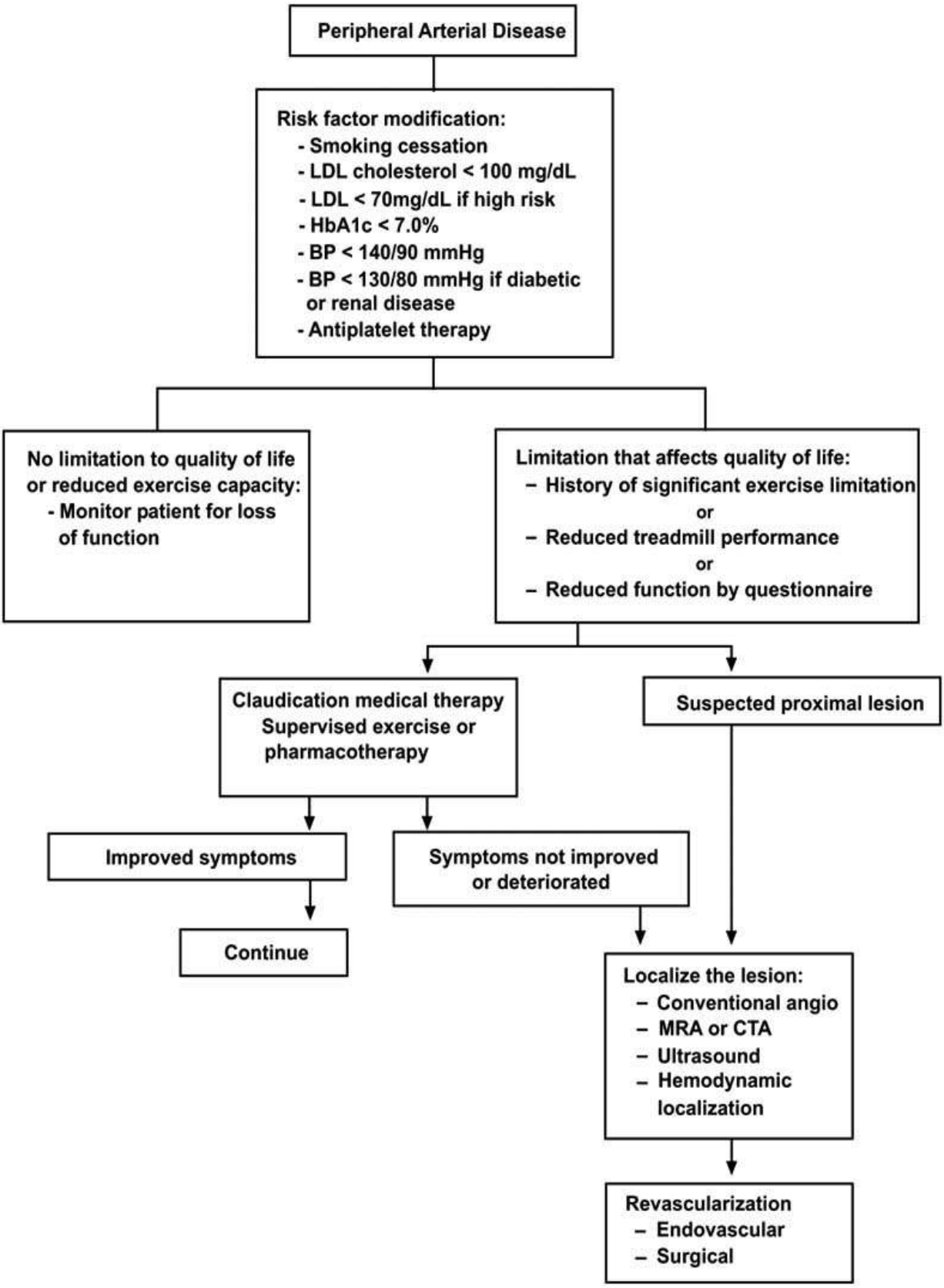

Figure No.6:- Overall Treatment Strategy for Peripheral Arterial Disease (21).

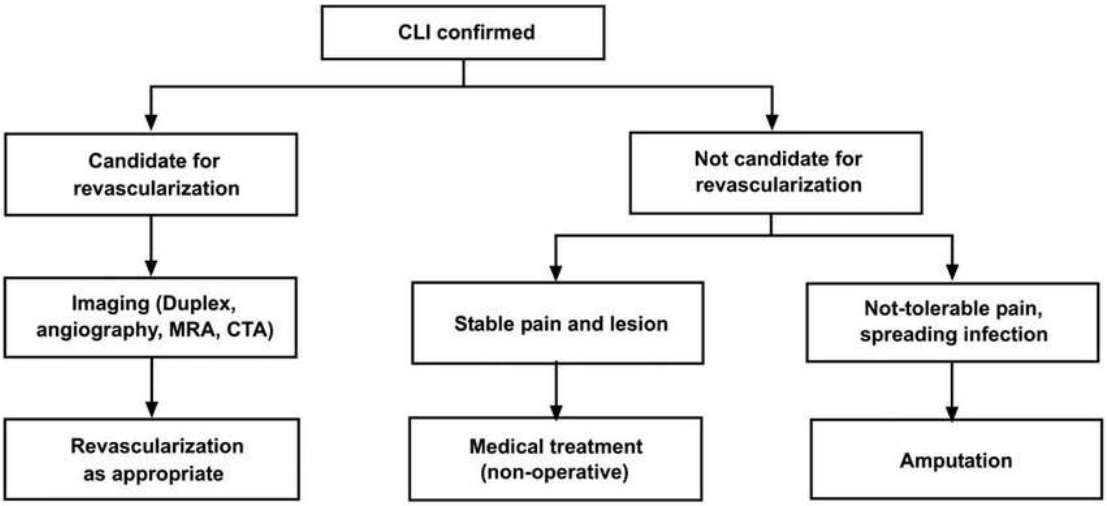

Figure No.7:- Algorithm for Management of CLI (22).

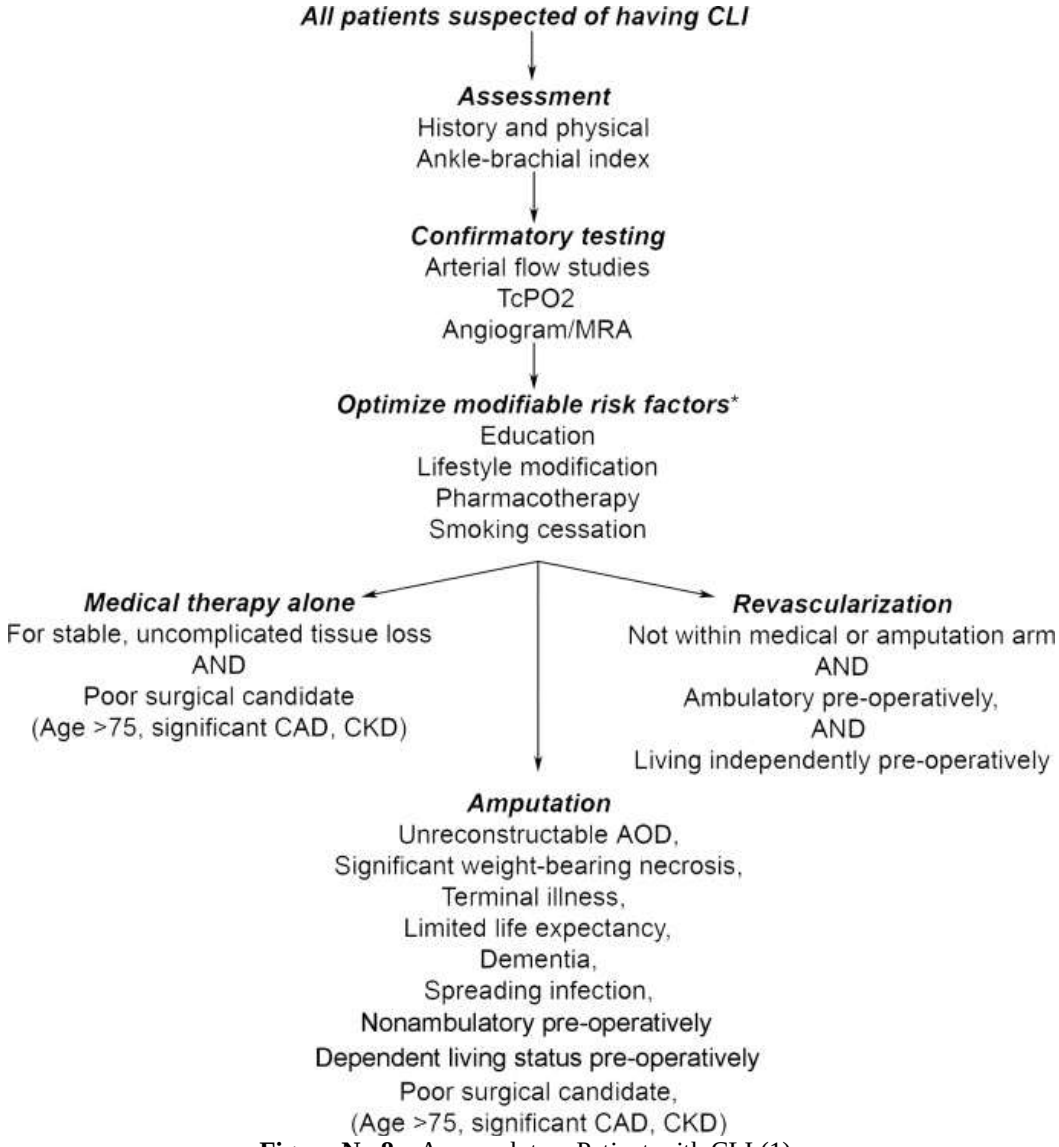

Figure No.8:- Approach to a Patient with CLI (1).

Management Of CLI (23)
The goals of treatment of CLI are to relieve the ischemic pain, heal ulcers, prevent limb loss, improve patient function and quality of life and to prolong survival .Most patients will ultimately have to undergo revascularization to achieve these goals.

Medical Therapy for Critical Limb Ischemia
These include (4)-
Pain relief – Initially NSAIDs or paracetamol are used for pain relief but later narcotic drugs are required. Pain relief is better if analgesics are given regularly instead of on demand. It is also advised to keep the affected limb in dependent position to help relieve the ischemic pain in addition to analgesia.

Wound care – This is by ensuring adequate perfusion of the ischemic limb, good nutrition, preventing infections and other mechanical factors that may interfere with wound healing. In case of an infected wound regular debridement will be required before healing can occur. Debridement by hydrotherapy, negative pressure therapy can also be done.

Systemic antibiotics in patients with cellulitis or other spreading infections.

Reports have shown (24) a 3 to 6 month course of Cilostazol to be effective in relieving symptoms of claudication.

Control of diabetes, blood pressure, lipid levels.

Use of antiplatelets in all symptomatic patients with or without cardiovascular disease, to reduce cardiovascular morbidity and mortality.

Management of coronary artery disease, renal artery disease in PAD.

Use of Prostaglandins, Vasodilators, Anticoagulants, Vasoactive drugs.

Hyperbaric oxygen, spinal cord stimulation are some other treatment modalities available.

Surgical Management of CLI
Surgical intervention (25) in CLI is indicated to salvage a useful and pain-free extremity. The mode of treatment depends upon the pre-morbid condition of the patient, the limb, the risk of intervention based on co-morbid conditions and the expected patency and durability of the reconstruction. There must be adequate inflow prior to improvement in outflow. After revascularization, ulcer healing may require combined treatment from vascular specialist and foot care specialists.

Endovascular Treatment of CLI
This is done (26) by percutaneous angioplasty with or without adjunctive atherectomy (mechanical or laser) and with or without adjunctive stenting.

Contraindications for endovascular treatment include low estimated glomerular filtration rate, anatomically unfavorable disease (common femoral artery lesion, extensive calcification, long segment occlusions, severe popliteal and/or infrapopliteal disease).Thrombosis, embolization, blue toe syndrome, amputation, loss of surgical target for bypass, access site complications (hemorrhage, pseudoaneurysm, arteriovenous fistula), contrast nephropathy, and renal failure are some of the complications associated with percutaneous angioplasty.

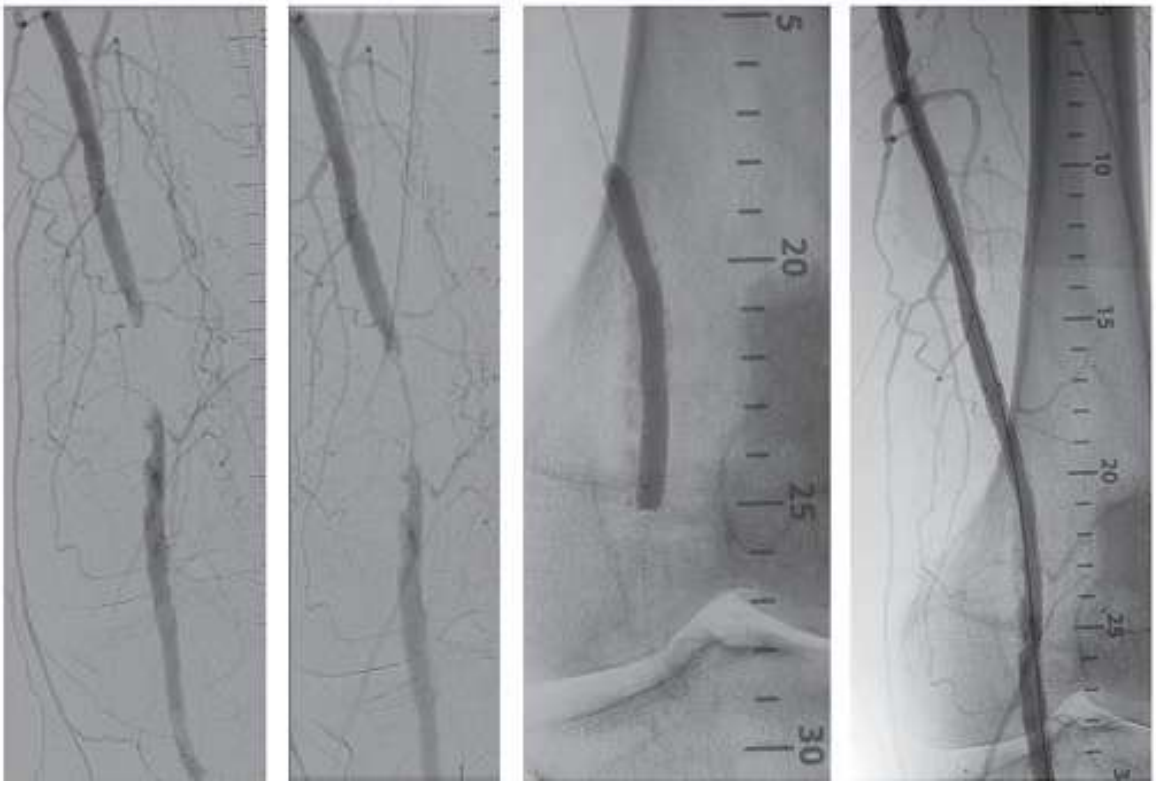

Figure No.9:- Endovascular Procedure – Left Femoropopliteal Junction Stenting (26).

Surgical revascularization (26)

Revascularization is the optimal treatment for patients with CLI**.** Surgical revascularization (4) is preferred for patients with complex lesions that are not amenable to catheter-based intervention and for younger patients with prolonged life expectancy who require a more durable revascularization and for patients who are relatively fit, can withstand the rigors of an open procedure, and have a life expectancy greater than 2 years.

Salvage Procedures

Limb salvage (27) after revascularization should be attempted if possible. A waiting period of at least 3 days has been suggested. This allows for sufficient time for the restoration of perfusion and for demarcation to occur. The level of adequate circulation, extent of infection, if any and remaining function of the foot are factors considered when choosing the level of a foot salvage procedure.

Prognosis of CLI

Of all patients with CLI, approximately 25% will have died and 25% will have required a major amputation (22). The diagnosis of CLI is thus a poor prognosis for life and limb. Ultimately, much of the care of CLI patients is palliative in nature, which is very important while considering revascularization or amputation.

Future Aspects In The Treatment Of Critical Limb Ischemia

1. Intramuscular gene transfer utilizing naked plasmid DNA encoding phVEGF165.(1)
2. Intramuscular injection of autologous bone-marrow mononuclear cells to stimulate vascular growth.(1)

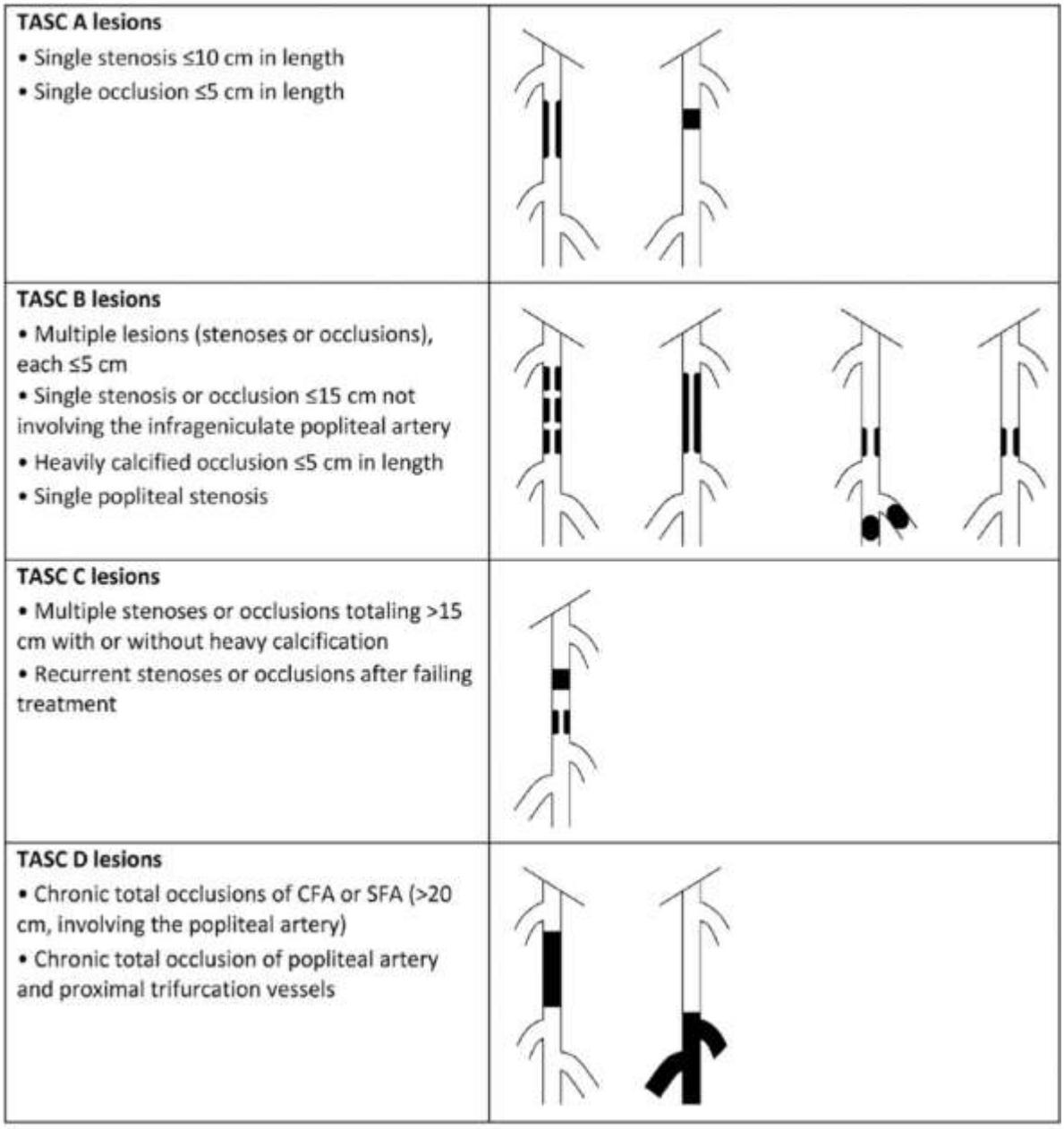

Figure No.10:- Trans-Atlantic Inter Society Consensus Classification II (TASCII),

Based On Angiogram, Classification Of CLI, TASC II A And B Lesions Are Treated By Endovascular Revascularization. From TASC II C And D Lesions Onwards Bypass Surgery Is Done (4).

Infrainguinal Bypass Procedure

For Femoropopliteal bypass (25), reversed saphenous vein is the best conduit. Patient with unsuitable saphenous vein (those with thrombosis, varicosities) are offered PTFE graft. femorodistal bypass, reversed saphenous vein graft is always used (28). All PVD patients with CLI preoperatively underwent detailed clinical examination, ABPI, cardiac evaluation (ECG, ECHO), blood investigations (haemogram, LFT, RFT) and peripheral angiogram is done. TASC II C (4) or further lesions bypass surgery is considered.

Based on angiogram findings, most distal inflow vessel is selected. Common femoral artery is used for femoropopliteal bypass, either common femoral or popliteal artery can be used

for femorodistal bypass. All patients are heparinised with 100 units/kg before clamping the artery. Suture material for proximal and distal anastomosis are (6-0) and (7-0) prolene respectively. The proximal and distal bypass is done using continuous parachute technique. Postoperatively suitable antibiotics are given according to culture and sensitivity, epidural analgesia and heparin continued for 48 hours. Suture removal is done on postoperative day 14.

In multilevel disease, the inflow must be assessed anatomically or with pressure measurements and occlusive disease should be treated before proceeding with an outflow procedure. Some cases require a combined approach with dilatation of proximal lesions and bypassing of distal lesions. A recent study shows an increasing trend towards complex bypass grafts (composite and spliced vein) to more distal arteries in patients with greater co-morbidities, such as diabetes, renal failure and coronary artery disease although mortality rates have remained constant. Another study showed that the morbidity or mortality of lower extremity revascularization was not affected by gender.

Infra-inguinal bypass procedures are done from a patent and uncompromised inflow artery although the actual level (common femoral artery versus superficial femoral or popliteal artery) does not correlate with patency. Patency of the graft is improved by making the proximal anastomosis to a native artery instead of the inflow graft (usually limb of aorto-bifemoral bypass) if the infra-inguinal bypass is constructed following inflow procedure. The quality of the outflow

Artery is a more important factor in determining the patency than the actual level where the distal anastomosis is performed. The best quality distal vessel should be used for the distal anastomosis.

Inflow artery for femoro-distal bypass can be any artery, regardless of level (i.e. not only the

Common femoral artery), provided that the flow to that artery and the origin of the graft is not compromised. In a femoral-tibial bypass, the femoral distal bypass outflow vessel should be the least diseased distal artery with the best continuous run-off to the ankle/ foot regardless of location, provided there is adequate length of suitable vein .For femoral below-knee popliteal and distal bypass, the long (greater) saphenous vein is the optimal conduit. If that is not available, another good quality vein should be used.

Figure No.11:- Harvesting of GSV.

Figure No.12:- Vertical Groin incision and Harvesting of GSV.

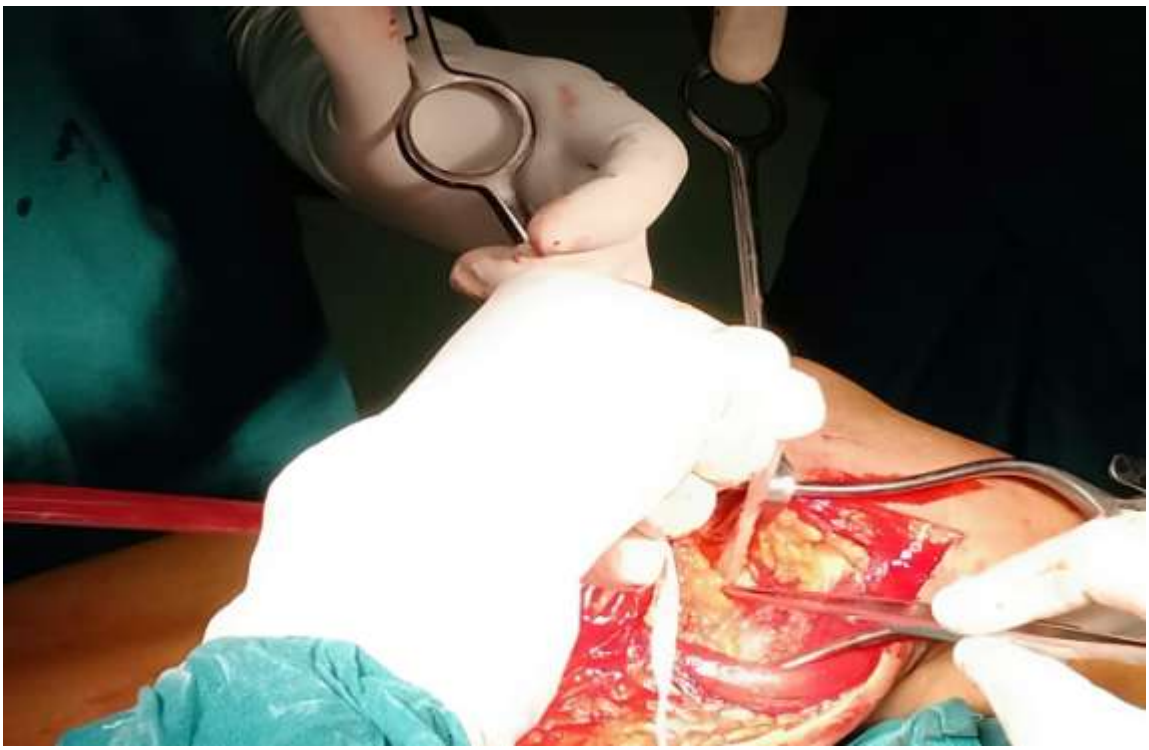

Figure No.13:- Distal Reversed GSV to Popliteal Artery Anastomosis.

Figure No.14:- Proximal reversed GSV to Common femoral artery Anastomosis.

Figure No.15:- Reversed Saphenous Vein Graft in Sub Sartorial Tunnel.

Introduction:-

Review of Literature:-

The review of literature was conducted for assessment of the data available regarding the outcome of infra-inguinal bypass in CLI and the studies are as follows:

1. Wound healing and functional outcomes after infra-inguinal bypass with
Reversed saphenous vein for critical limb ischemia. (Chung et al, 2006. Journal of vascular surgery, 43:6: 1183-1190)

Patients undergoing infra-inguinal bypass for CLI were retrospectively entered into a technical and functional outcomes database. These patients were enrolled from the tertiary referral vascular surgery practices at the University of Colorado Health Sciences Center and Southern Illinois University Medical School. Main outcome variables were wound healing, self-assessed degree of ambulation (outdoors, indoors only, or non-ambulatory) and living status (community or structured) after a mean follow up of 30 ± 23 months. These outcome variables were assessed with respect to the preoperative clinical features (symptom duration before vascular consultation, lesion severity, and serum albumin level) and graft patency.

Results:-

From August 1997 through December 2004, 334 patients (253 men; median age, 68 years) underwent 409 infra-inguinal bypasses (157 popliteal, 235 tibial, and 17 pedal) for CLI (159 Fontaine III and 250 Fontaine IV). Perioperative mortality was 1.2%. At 1 and 3 years, the primary patency was 63% and 50%, assisted primary patency was 80% and 70%, limb salvage was 85% and 79%, and survival was 89% and 74% respectively. Complete wound healing at 6 and 12 months was 42% and 75%, respectively. 34 patients (10%) died before all wounds were healed. Based on multivariate analysis, extensive pedal necrosis at presentation independently predicted delayed wound healing ($P \leq .01$). At baseline (defined as the level of function within 30 days before the onset of CLI), 91% of patients were ambulatory outdoors which decreased to 72% at 6 months ($P \leq .01$). Similarly, 96% patients lived independently at baseline but this decreased to 91% at 6 months ($P \leq .01$) Graft patency was associated with better ambulatory status at 6 months. Delay in vascular consultation after onset of symptoms was associated with a worse living status at 6 months.

2. Norgren L, et al: Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). Journal of Vascular Surgery 45(Suppl S):S5– S67, 2007.

The goals of this consensus were to provide an abbreviated document, to focus on-key aspects of diagnosis and management and to update the information based on new publications and the newer guidelines, but not to add an extensive list of references. Unreferenced statements are thus found, provided they are recognized as common practice by the authors, with existing evidence. The recommendations are graded according to levels of evidence. It must be emphasised that good practice is based on a combination of the scientific evidence, patients' preferences, local availability of facilities and trained professionals and appropriate specialist referral.

3. Femoro-popliteal bypass- In situ or reversed vein grafts?: Ten-year results of a randomized prospective study - J. Watelet, P. Soury, J.F. Menard, D. Plissonnier, C. Peillon, J.P. Lestrat, et Annals of Vascular Surgery, 11 (1997), pp. 510-519

100 femoropopliteal bypass procedures performed in 91 patients between October 1980 and January 1985 were randomly divided into two statistically comparable groups including 50 in situ vein grafts and 50 reversed vein grafts. The indication for the procedure was chronic CLI in 97% cases. In 75% cases, distal popliteal artery was the site for the lower anastomosis. Follow-up ranged from 10 years (for the last patient included) to 14 years. 3 patients were lost to follow-up. Median survival was 54 months in the in situ graft group and 76.5 months in the reversed graft group. Actuarial survival at 10 years was 30.8% in the in situ graft group and 29.5% in the reversed graft group, limb salvage at 10 years was 73.5% in the in situ graft group and 74.4% in the reversed graft group. 10 cases had graft occlusion during the perioperative period (six in the in situ graft group and four in the reversed graft group) and 19 cases during the late postoperative period (12 in the in situ graft group and seven in the reversed graft group). Repeat surgery during follow-up was required in 13 cases in the in situ graft group (11 patients) and in 9 cases in the reversed graft group (five patients).Actuarial primary patency at 10 years was 41.7% in the in situ graft group and 64.5% in the reversed graft group ($p < 0.05$), secondary patency at 10 years was 64.8% in the in situ graft group and 70.2% in the reversed graft group (NS). Actuarial secondary patency at 10 years, as a function of vein diameter, in the in situ graft group was 37.5% for bypasses using veins with a diameter of 4 mm or less and 80.6% for bypasses using veins larger than 4 mm ($p < 0.05$). The actuarial secondary patency rate in the reversed graft group was 71.2% for bypasses using veins with a diameter of 4 mm or less and 65.5% for bypasses using veins larger than 4 mm. The problems raised by the in-situ technique include requiring a training period and valve removal, particularly for small diameter veins. The absence of these disadvantages makes the reversed technique the procedure of choice for femoropopliteal bypass.

4. Bypass Surgery for Lower Extremity Limb Salvage: Vein Bypass- Methodist Debakey Cardiovascular Journal. 2012 Oct-Dec; 8(4): 37–42

This article discusses infra-inguinal vein bypass surgery including indications, perioperative care and long-term follow up. It also discusses the outcomes of the procedure with regard to patient survival and limb salvage. The best treatment option is the autogenous vein with the highest patency rate. Compared to all other revascularization options for infra-inguinal disease, the vein bypass has the best limb salvage and long-term survival in patients appropriately selected for the procedure.

Results:
For femoro-popliteal graft with reversed GSV 6month primary patency is 91%, for infra-popliteal graft with reversed GSV it is 81% and for below knee femoro-popliteal graft with reversed GSV, it is 90%.

5. Predicting ambulation status one year after lower extremity bypass- Goodney et al Journal of Vascular Surgery Volume 49,

This is a prospective registry of 1561 lower extremity bypass procedures performed for occlusive disease (2003-2005) in1400 patients (50 surgeons, 11 hospitals). Ambulatory status was assessed preoperatively, at discharge, and at 1-year by life-table analysis. Cox proportional hazards models were used to determine the predictors of ambulatory status 1 year postoperatively.

Results:
The indication for surgery was claudication in 25% and critical limb ischemia (CLI) in 75% of the patients. Patients with claudication had higher primary (79% vs 73%, P<.001) and secondary (87% vs 81%, P<.001) graft patency rates and were more likely to be alive and ambulatory 1 year postoperatively (96% vs 81%, P<.001) than CLI patients. Amputation rates were 12%for CLI patients and 1% for claudicant patients (P<.001). All claudicant patients walked before surgery, and the 95%who survived 1 year postoperatively remained ambulatory. Among CLI patients, preoperatively 93% were ambulatory and88% of the survivors at 1 year remained ambulatory.

6. Healing of Ischemic Tissue Lesions after Infrainguinal Bypass Surgery for Critical Leg Ischemia - M. Soderstrom et al (2008 European Society for Vascular Surgery.)

In this study, patients with CLI and tissue loss (Fontaine IV) (148 patients, 150 limbs) were followed up for 1 year after infra-inguinal bypass. Wound healing, graft patency, limb salvage, survival rates and the overall need for any type of surgical and endovascular procedures were analysed. Patient comorbidities were assessed by uni- and multivariate analysis to determine risk factors for adverse outcome.

Results:
Complete tissue healing, including healing of ischemic tissue lesions and surgical wounds at 6 and 12 months after the infra-inguinal bypass were respectively 40% and 75%. The median time for complete tissue healing was 190 days. Diabetes was the only significant risk factor which caused delayed tissue healing. Overall patency, limb salvage, survival and amputation-free survival rates at 1year were 80%, 81%, 73% and 63% respectively. The clinically important outcome of amputation-free survival with completely healed wounds was attained in 50% of patients at 1 year.

Conclusion:-
Complete healing of ischemic tissue lesions is slow even after a successful infra-inguinal bypass.

Aim and Objectives:-
Aim:-
A study to determine the short term outcome of infrainguinal bypass in critical limb ischemia.

Objectives:-
To assess the following in CLI after infra-inguinal bypass surgery:
1) Wound healing

2) Limb salvage
3) Self assessed degree of ambulation
4) Primary patency of graft using arterial Doppler

Materials and Methods:-

Study Design:
Cohort study (single directional)

Study Setting:
Amala Institute of Medical Sciences

Study Period:
January 2018 to June 2019

Study Subjects:
Patients attending PVD clinic in Department of Surgery, Amala Medical College.

Inclusion Criteria
All PVD patients with CLI

Exclusion Criteria
1) Patients with non-reconstructable CLI, (that is occlusion of arterial tree with no Reformation made out on angiogram) were excluded.
2) CLI with non-salvageable limb at presentation were excluded.
3) CLI treated with endovascular procedures (TASC II A and B lesions) are excluded

Statistical Considerations
Sample Size:
n = sample size
p = prevalence-68% (degree of independent ambulation reference-7)
q = 1 - p
d = 20% error of prevalence
$\alpha = 0.05$
Power = 80%
$n = (z\alpha pq) = 48$
Thus the minimum sample size required is 48.

Methods Of Data Collection:-

The study included PVD patients with CLI who has undergone infra-inguinal bypass surgery. PVD patients with CLI were assessed preoperatively by detailed clinical examination, ABPI, cardiac evaluation (ECG, ECHO), routine preoperative blood investigations (hemogram, LFT, RFT) and peripheral angiogram. Periodic assessment was also done during postoperative hospital phase, at 1 month and 6 months. Primary graft patency was checked at 6 months using arterial doppler.

Statistical Analysis
The data was entered into MS excel and analysis done by SPSS (Version 23). The difference in functional outcome and wound healing before and after bypass surgery will be done by Mantel-Haenszel test.

Results:-

Demographics
1) Age
The details of the patient included in our cohort are shown in Table nos.2 and 3
Table No.2:- Mean and Standard Deviation of Age.

	Mean	Standard Deviation
Age (in years)	65.27	8.381

Table No.3:- Age Distribution.

Age (in years)	Frequency	Percent
≤55	6	12.5
56-65	22	45.8
66-75	14	29.2
≥76	6	12.5
Total	48	100.0

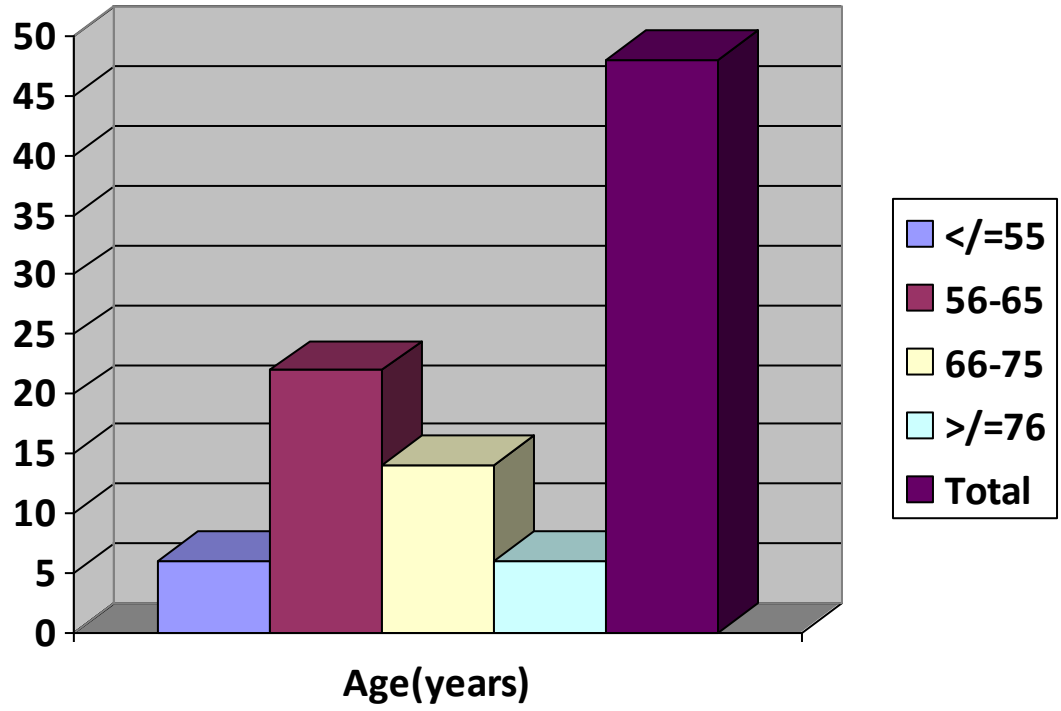

Figure No.16:- Age Distribution.

2) Sex

Table No.4:- Sex Distribution.

Sex	Frequency	Percent
Female	11	22.9
Male	37	77.1
Total	48	100

3) Limb Affected

Table No.5:- Distribution Based On Limb Affected.

Limb Affected	Frequency	Percent
Left	25	52.0
right	22	45.9
Left and Right	1	2.1
Total	48	100.0

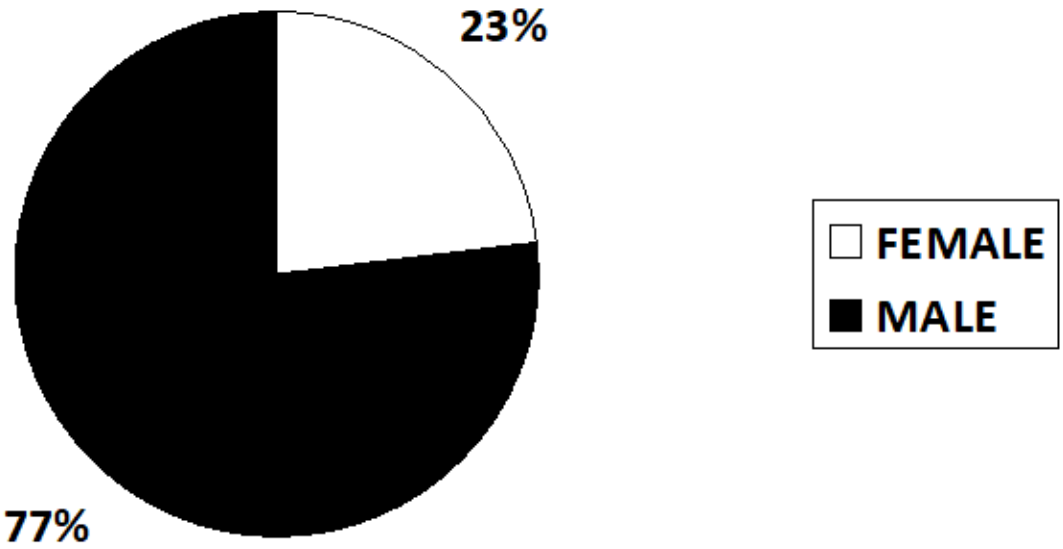

Figure No.17:- Sex Distribution.

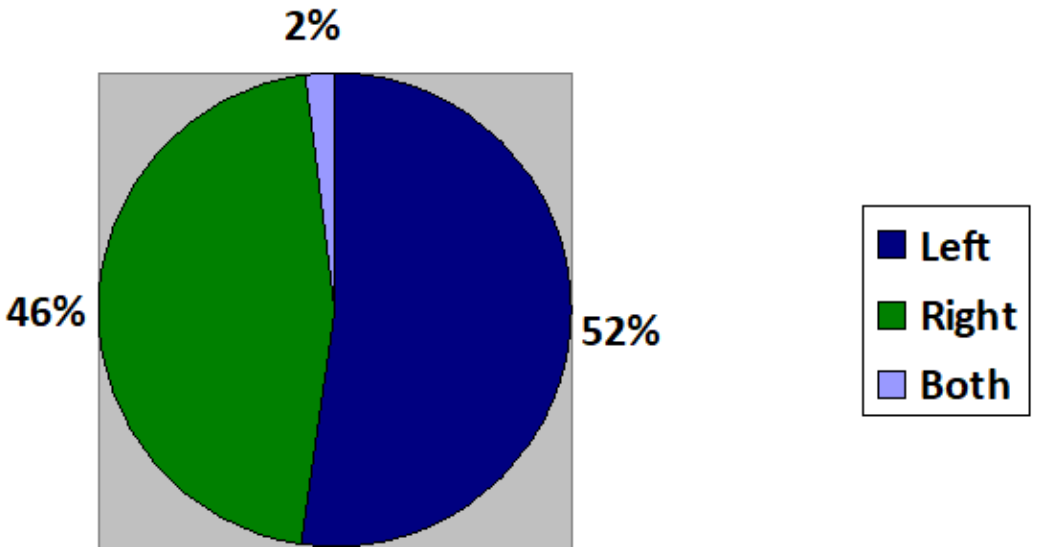

Figure No.18:- Limb(s) Affected.

Associated Co-Morbidities

Table No.6:- Distribution Based On Associated Co-Morbidities.

	Yes		No	
	Frequency	Percent	Frequency	Percent
Diabetes	38	79.2	10	20.8
Hypertension	30	62.5	18	37.5
Dyslipidemia	35	72.9	13	27.1
CAD	20	41.7	28	58.3
CKD	3	6.3	45	93.8
COPD	4	8.3	44	91.7
CVA	4	8.3	44	91.7

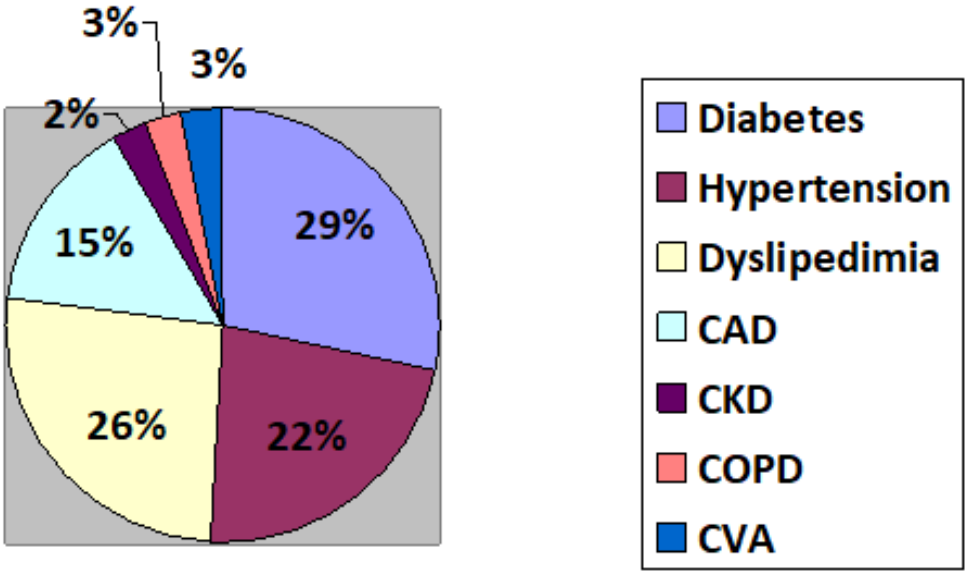

Figure No.19:- Associated co-morbidities.

Association With Smoking

Table No.7:- Association with Smoking.

	Frequency	Percentage
Former Smoker	9	18.8
Current Smoker	30	62.5
Non Smoker	9	18.8

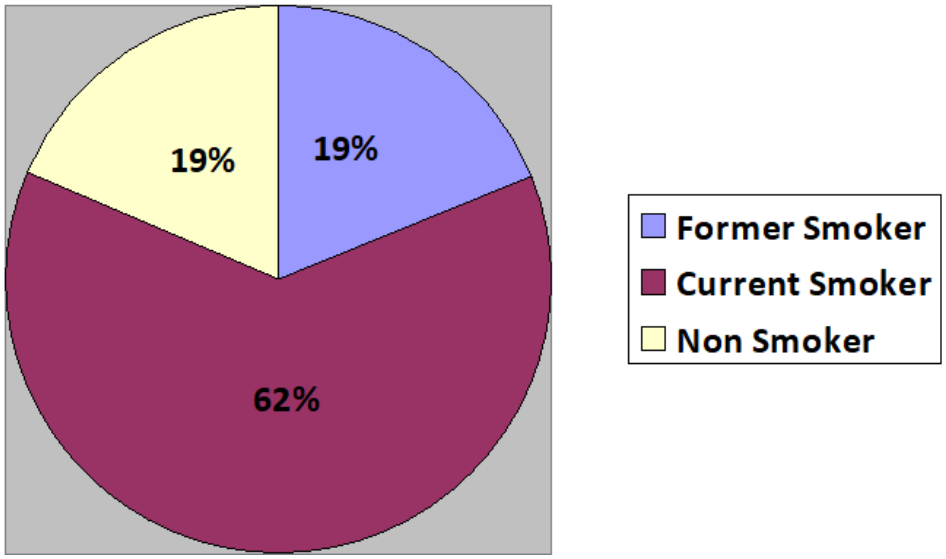

Figure No.20:- Association with Smoking.

Presentation of The Disease

Table No.8:- Presentation of the Disease.

	Frequency	Percentage
Presentation with rest pain	14	29.2
Presentation with ulcer or gangrene	34	70.83

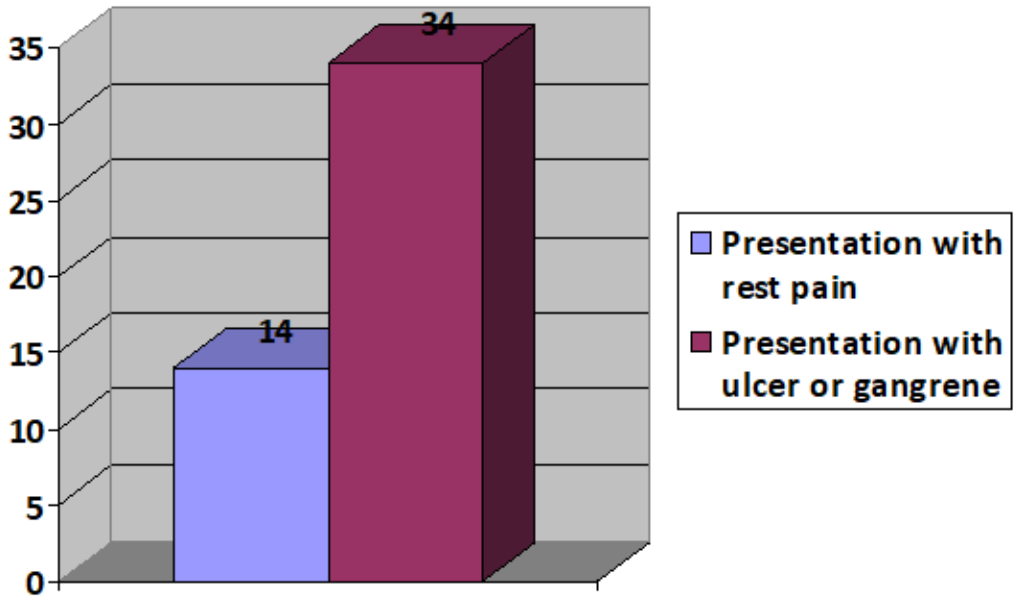

Figure No 21:- Presentation of the Disease.

Fontaine Stage Of Disease

Table No.9:- Fontaine Stage of the Disease At Presentation.

Fontaine stage	Frequency	Percentage
III	12	25.0
IV	36	75.0
Total	48	100.0

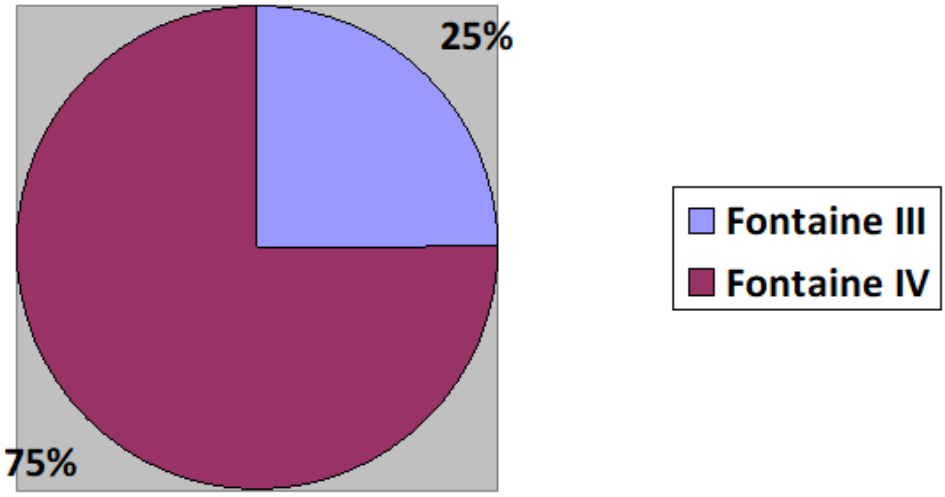

Figure No.22:- Fontaine Stage of the Disease At Presentation.

Type Of Infrainguinal Bypass

Table No. 10:- Type Of Infrainguinal Bypass.

Type of Bypass	**Frequency**	**Percentage**
Femoro-Popliteal Bypass(1)	**37**	**77.083**
Femoro-Distal Bypass(2)	**11**	**22.917**
Total	**48**	**100**

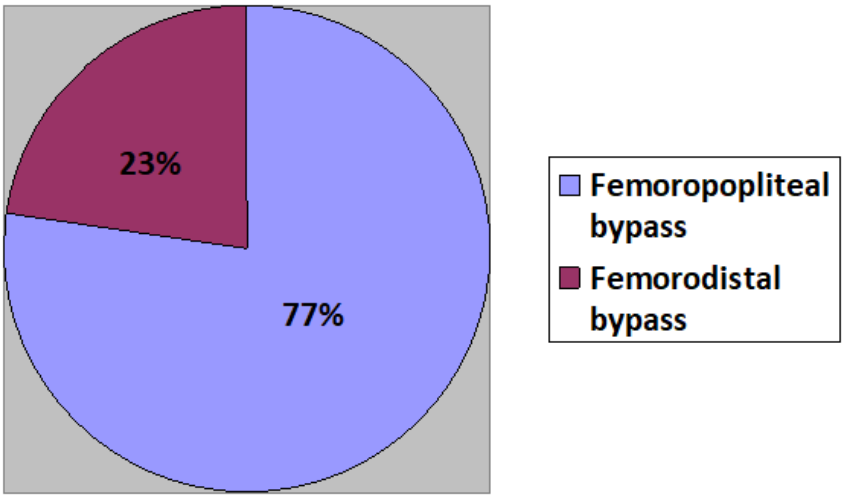

Figure No.23:- Type of Infrainguinal bypass.

In our patients, all had Common femoral Artery as inflow vessel.

77% cases had femoropopliteal bypass and 23 % cases had femorodistal bypass.

Mean Duration Of Hospital Stay

Table No.11:- Mean Duration of Hospital Stay.

	Mean	Std. Deviation
Days of hospital stay	10.542	3.2809

Wound Healing

Table No.12:- Wound Healing At 1 Month and 6 Months.

	Yes	No	Total
Wound healing at 1 month	19	29	48
Wound healing at 6 months	37	11	48

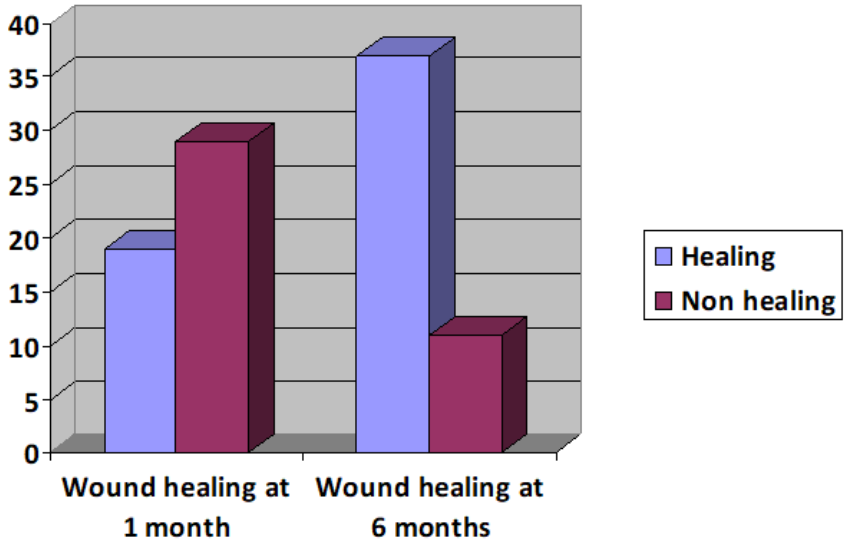

Figure No.24:- Wound Healing At 1 Month And 6 Months.

Mc Nemar Test p value=0.0001

Percentage: Wound healing at 1 month- 39.58%
Wound healing at 6 months- 77.08%

Limb Salvage

Table No.13:- Limb Salvage at 1 Month and 6 Months.

	Yes	No	Total
Limb salvage at 1 month	42	6	48
Limb salvage at 6 month	42	6	48

Mc Nemar Test p value=0.0001
Limb salvage at 1 month and 6 months is 87.5%.

Self Assessed Degree Of Ambulation

Table No.14:- Self Assessed Degree of Ambulation at 1 Month and 6 Months.

	1*	2*	3*	Total
Self-assessed degree of ambulation at 1 month	1	43	4	48
Self-assessed degree of ambulation at 6 months	9	29	10	48

Mc Nemar Test p value=0.001
1*- Ambulatory outdoors (the ability to ambulate outside the home with or without an assist device),
2*- Ambulate indoors (the ability to ambulate only inside home)
3*- Non-ambulatory (the inability to ambulate and need for transfer assistance).

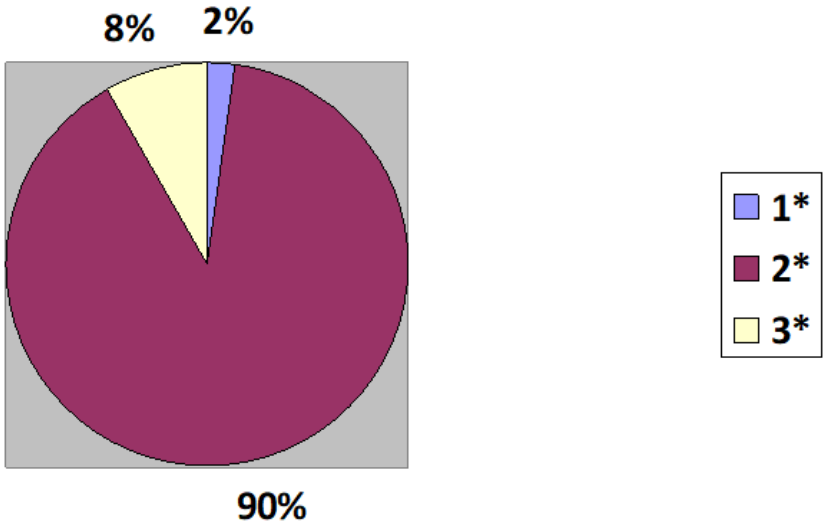

Figure No.25 A:- Self-Assessed Degree of Ambulation at 1 Month.

Primary Patency Of Graft At 6 Months

Table No.15:- Primary Patency of Graft at 6 Months.

Primary patency of graft	Frequency	Percent
Absent	10	20.8
Patent	38	79.2
Total	48	100.0

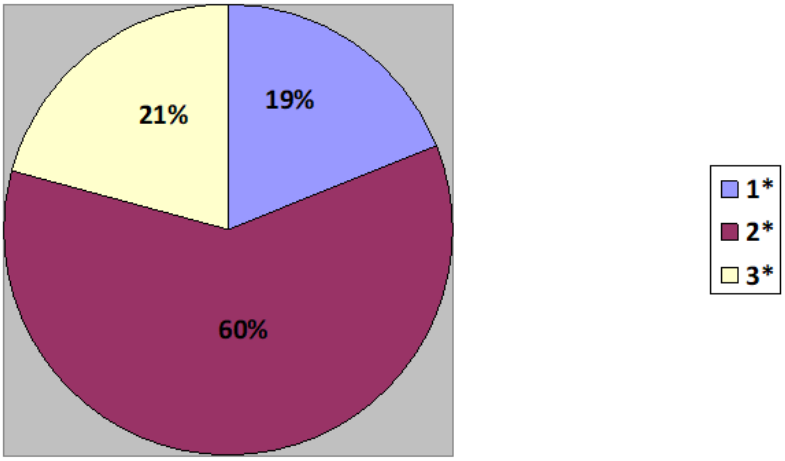

Figure No.25B:- Self-Assessed Degree of Ambulation at 6 Months.

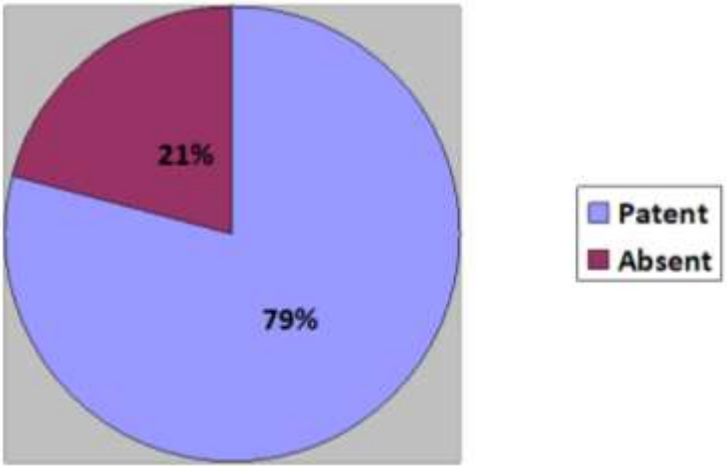

Figure No.26:- Primary Patency of Graft at 6 Months.

Discussion:-

CLI is an end stage of peripheral arterial disease .CLI is a clinical diagnosis. It should be confirmed objectively through ABI, toe systolic pressure, or transcutaneous partial pressure of oxygen. Once the diagnosis is confirmed, the goals of treating CLI are to relieve ischemic pain, heal ischemic ulcers, prevent limb loss, improve patient function and QOL and prolong survival.

The aim of the study is to assess the outcome of infra-inguinal bypass surgery in all PVD patients who presented to our General Surgery department with CLI.

Our cohort consists of 48 patients with a mean age of 65.27 years. There were 11 females and 37 males. 52% of the patients have an affected left limb, 45.9% have an affected right limb and 2.1 % have bilateral presentation. Patients also had co-morbidities in the form of type 2 diabetes mellitus in 79.2% cases, hypertension in 62.5% cases, and dyslipidemia in 72.9% cases, coronary artery disease in 41.7% cases, chronic kidney disease in 6.3% cases and Cerebrovascular and chronic obstructive pulmonary disease in 8.3% cases.

Out of 48 patients, 62.5 % cases are current smokers, 18.8 % are reformed and non-smokers. 75% cases were at Fontaine stage IV at presentation and rest 25% were at Fontaine III. After preoperative blood investigations, cardiology evaluation, peripheral Angiogram and anaesthesia evaluation, our patients underwent infra inguinal bypass with reversed saphenous vein graft. All our patients' inflow vessel was common femoral artery. 77.083% cases had femoropopliteal bypass and 22.917 cases had femorodistal bypass. Also, periodic assessment was done

during postoperative period at 1 month and 6 months. Primary graft patency was checked at 6 months using arterial doppler.

The mean duration of hospitalization was 10.542 with standard deviation of 3.2809.There was no perioperative mortality.

In our study, wound healing observed at 1 month is 39.58% , which was increased to 77.08 % at the end of 6 months(Mc Nemar Test p value=0.0001).Limb Salvage attained at the end of 6 months is 87.5%.

Ambulatory status of the patients were assessed at the end of 1 month after surgery and only 2% were ambulatory outdoors, 90 % were ambulating indoors and 8% were non-ambulatory. Total ambulatory status post-surgery (indoor and outdoor combined), came around 92% at 1 month. At 6 months post-surgery, 19 % of patients were ambulating outdoors, 60 % were ambulating indoors and 21 % were non-ambulatory. Total ambulatory status at 6 months (indoor and outdoor combined), post-surgery came around 79 %. (Mc Nemar Test p value = 0.001). Primary patency of the graft at 6 months for our cohort is 79.2%.

According to Chung et al, perioperative mortality was 1.2%, wound healing at 6 months was 42%, limb salvage attained was 85 %, ambulatory status attained was 72% and primary graft patency was 63%. On comparing with our results, we had no perioperative mortality, 77.08% wound healing, 87.5 % limb salvage, 79% ambulatory status and 79.2 % primary graft patency. Thus in comparison, we had better wound healing, limb salvage, ambulatory status and primary graft patency.

Results	Our Study	Chung et al
Perioperative mortality	Nil	1.2%
Wound healing at 6 months	77.08%	42%
Limb salvage	87.5%	85%
Ambulatory status	79%	72%
Primary graft patency	79.2%	63%

According to Goodney et al, wound healing at 6 months was 40 %, limb salvage was 81% and primary graft patency was 73 %.

Results	Our Study	Goodney et al
Wound healing at 6 months	77.08%	40%
Limb salvage	87.5%	81%
Primary graft patency	79.2%	73%

Results	Our Study	M.Soderstorm et al
Wound healing at 6 months	77.08%	40%
Limb salvage	87.5%	81%
Primary graft patency	79.2%	80%

According to M.Soderstorm et al, wound healing at 6 months was 40%, limb salvage was 81% and primary graft patency was 80%.

According to Jacques Watelet et al, primary patency of graft was 64.5%, whereas our study had 79.2% graft patency.

According to Debakey et al, primary patency of femoropopliteal graft was 91% and that of infrapopliteal graft was 81%.

On comparison with the above studies, our patients with CLI who has undergone infrainguinal bypass with reversed great saphenous vein graft has superior limb salvage, better wound healing, ambulatory status and primary graft patency.

Conclusion:-

This Study includes 48 patients with CLI who has undergone infrainginal bypass with reversed saphenous vein graft. 87.5% limb salvage, 77.08% wound healing at 6 months, 79% was ambulatory status at 6 months and 79.2% primary graft patency were attained.. 7 out of 8 CLI patients treated surgically has limb salvage and good functional status.

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