International Journal of Research in Medical Sciences
Kumar UK et al. Int J Res Med Sci. 2016 Nov;4(11):4675-4682
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20163641

Original Research Article

Evaluation of peripheral arterial occlusive disease by computed tomography angiography

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Received: 22 September 2016
Accepted: 01 October 2016

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ABSTRACT

Background: Characterization of peripheral arterial occlusive disease (PAOD) can be performed with non-invasive angiography using computed tomography (CT). The present study was conducted to evaluate the CT angiographic spectrum of aortoiliac and the lower limb arterial disease in symptomatic patients of peripheral arterial occlusive disease (PAOD) and to classify the lesions according to the Trans-Atlantic Inter-Society Consensus II (TASC II).
Methods: The study was carried out in the department of radio-diagnosis in collaboration with departments of cardiothoracic surgery, cardiology and surgery, Safdarjung Hospital and Vardhman Mahavir Medical College, New Delhi. 50 patients aged above 40 years presenting with symptoms and (or) signs of lower limb peripheral arterial disease were recruited into the study after evaluating the renal function. Patient's clinical history, ABI index and categories of PAOD according to the classification of Fontaine was noted. CT angiography of aortoiliac and lower limb arteries was performed with Philips Brilliance 40 CT unit. The findings in each CT angiography were analysed in respect to site, number, nature and distribution of the lesions and classified individually according to the TASC II.
Results: The patients included in the study were all more than 40 years of age. The age range in the study group was 42 years to 75 years. The majority (86%) were male patients. Smoking and dyslipidemia were found to be the main risk factors in our patients. 24% of patients had documentary evidence of ischemic heart disease. On grading with ABI majority of patients (58%) presented in the end stage of the disease (stage IV). On CT angiography, number of lesions detected was 157. 97.4% of lesions were either stenotic or occlusive and 2.54% are with aneurysm. Maximum number of patients had femoropopliteal lesions followed by aortailiac lesions. 14 Winslow pathways were found in 10 patients. Maximum numbers of femoropopliteal lesions (47.29%) belong to type D, type B lesions account for 50% of total aortoiliac lesions based on TASC II classification. Out of 50, 40 were made follow up. Among them 8 were managed with conservative treatment and remaining 32 managed with treatment based TASC II classification.
Conclusions: CT angiography is a reliable noninvasive imaging method for the comprehensive and multi parameter evaluation of patients with PAOD. CT angiographic findings are a highly accurate basis for treatment decisions and planning.

Keywords: Peripheral arterial occlusive disease, CT angiography, TASC II

INTRODUCTION

Worldwide cardio vascular disease accounts for approximately 30% of death; for which atherosclerosis is the basic pathology.[1] Peripheral arterial occlusive disease (PAOD) is one of the many manifestations of atherosclerosis. Patients with PAOD have a 5 year mortality rate of 15-30% and a two-six fold increased risk

of death from coronary heart disease.[2] Studies show, coronary artery disease (CAD) is associated with aortoiliac lesions in 40.5% of patients undergoing coronary angiography.[3] In contrast to coronary artery afflictions, PAOD is commonly under diagnosed and under treated.[4]It causes intermittent claudication, gangrene and can jeopardize limb viability.[2] So, early and accurate diagnosis of peripheral arterial disease in renal, abdominal and aortoiliac vessels is of paramount important for assessment of prognosis and overall management of PAOD patients.

Even though digital subtraction angiography is the diagnostic standard for the evaluation of PAOD, this technique has several disadvantages, such as invasiveness, high cost and high radiation.[5]Computed tomography (CT) angiography has the advantage of being a non-invasive rapid technique, acquiring diagnostic quality angiographic images in less than a minute and that too with the use of only intravenous contrast injection. Furthermore, eccentric stenosis, length of occlusions, collaterals, co-existent aneurysm and the surrounding soft tissues can be evaluated, which is not possible with conventional catheter angiography.[6] Studies on the role of CT angiography in PAOD management are still evolving.[5,7,8] Hence the present study was aimed to identify the spectrum of abnormalities in peripheral arteries of symptomatic PAOD patients (grade II-IV of Fontaine classification) and assess the role of CT angiography in deciding the management.

METHODS

The proposed study was carried out in the department of radio-diagnosis in collaboration with department of cardiothoracic surgery, department of cardiology and department of surgery. 50 patients aged above 40 years presenting with symptoms and (or) signs of lower limb peripheral arterial disease were recruited into the study after evaluating renal function. Selected patients were subjected to multi detector CT angiography of aortoiliac and lower limb arteries after getting the informed consent. Exclusion criteria were patients with impaired renal functions, upper limb arterial involvement and with congestive cardiac failure.

Patient's clinical history was evaluated and recorded for cigarette smoking, claudication, rest pain and ulcer. Clinical evaluation for the presence of hypertension and measurement of ankle brachial index (ABI) using sphygmomanometer and stethoscope was done. Based on pain free walking distance and the presence or absence of tissue loss, PAOD was categorized according to the classification of Fontaine.[9]

- Stage I: PAOD is asymptomatic. Intermittent claudication is classified as stage II.
- Stage IIa: indicates a pain-free walking distance greater than 200m; otherwise the disease is stage IIb.
- Stage III: PAOD is characterized by rest pain.
- Stage IV: PAOD characterized by ulcerations and (or) gangrene

CT angiography

CT angiography of aortoiliac and lower limb arteries was performed with Philips Brilliance 40 CT unit. Patients were positioned supine with their feet first. Patient's feet were secured at a slight degree of internal rotation to separate the tibia from the fibula and, consequently, the trifurcation vessels from the bones. After the acquisition of a 1400.0mm initial topogram, the acquisition volume was repositioned for examination of an arterial segment extending from the diaphragm to the feet. The volume varied in length, depending on the height of the patient.

An 18-gauge intravenous cannula was inserted into a superficial vein in the antecubital fossa, forearm, or dorsum of the hand. Multidetector row CT angiography was performed after intravenous injection of 120 ml of the contrast medium at a flow rate of 4.5 ml/sec with 40ml of saline chaser in a rate of 4ml/sec, using a programmable double barrel power injector to provide the bolus duration of 36 seconds. A high-iodine concentration non-ionic contrast agent (Omnipaque-350) was used for the study.

Multidetector row CT angiography was performed by using 40 × 0.625 mm collimation, 0.9 mm section thickness, 0.45 mm increment and gantry rotation time of 0.5second. X-ray tube voltage and amperage will be 120 kV, 210 mAs. To assess the optimum time of scanning, automated bolus triggering technique was used and the cursor was placed at a point just above the level of celiac axis. Post scan processing was done using multi planar reconstruction, curved planar reconstruction, maximum intensity projection (MIP), volume rendered imaging. Semiautomatic bone editing was performed for construction of VRT and MIP. The vessels were tracked semi-automatically for computation of 3D branching tree of arterial centerlines.

The findings in each CT angiography were analysed in respect to site, number, nature and distribution of the lesions. The lesions were also classified individually according to the Trans-Atlantic Inter-society consensus (TSAC).[10] TASC guidelines define four categories (A, B, C, D) of aortoiliac and femoropopliteal lesions, depending on the degree, number, and length of stenoses. Endovascular procedure is the treatment of choice of patients with class A lesions (most benign) and surgery is the treatment of choice of patients with class D lesions (most severe). For patients with class B lesions, endovascular treatment is preferred, whereas surgery is preferred for patients at good risk with class C lesions.[7]

RESULTS

The clinical data of patients referred for CT angiography with clinical symptoms of PAOD were analysed. All the

patients underwent screening color doppler examination and their findings were consistent with atherosclerotic PAOD. The patients included in the study were all more than 40 years of age.

The age range in the study group was 42-75 years. The majority (86%) were male patients. Maximum number of patients (44%) belonged to 7th decade, followed by those in the 6th decade (24%). Age and sex wise distribution of patients is given in Table 1.

Table 1: Age and sex wise distribution of PAOD patients.

Age (years)	Male	Female
41-49	9	0
50-59	11	1
60-69	19	3
70-79	4	3

Detailed clinical history of all the patients was taken to assess the predominant risk factors and associated co morbid conditions. Figure 1 given below shows the risk distribution among the patients with atherosclerotic occlusive disease. Smoking and dyslipidemia were the main risk factors in our patients.

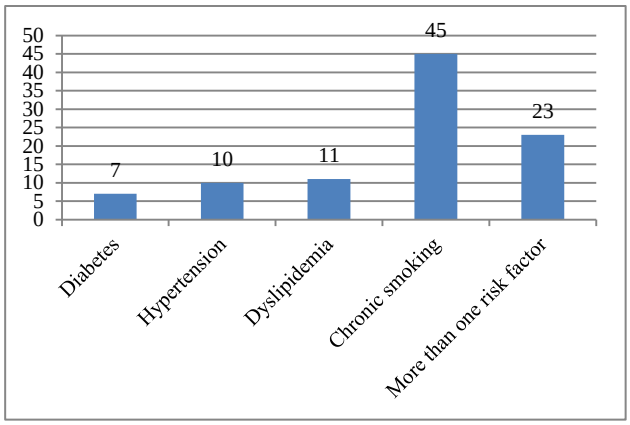

Figure 1: Risk factors of PAOD.

PAOD and CAD are all manifestations of atherosclerosis. Therefore, these conditions commonly occur together. History and details about CAD were obtained from all the patients and presented in Table 2. 24% of patients had ischemic heart disease and 3 of them had triple vessel diseases with subsequent bypass procedures.

Table 2: Number of patients with associated CAD.

Details of CAD	Number of patient (%)
Documentary evidence of CAD	12 (24%)
Single vessel disease	2 (4%)
Double vessel disease	4 (8%)
Triple vessel disease	3 (6%)

Clinical disease staging and sphygmomanometric measurement of ABI of the affected limbs was done for all the patients with PAOD. Table 3 shows that, majority of patients (58%) presented in stage IV either with ischemic ulcerations or gangrene in the lower limb. In most of the patients (66%) the BP was not recordable by sphygmomanometer at the ankle level, suggesting severe reduction of blood flow at this level showing ABI zero in these patients.

Table 3: Clinical staging of PAOD.

Clinical stage at presentation	Number of patients
Fontaine's classification	
I	0
IIa	7
IIb	8
III	6
IV	29
Ankle brachial index (ABI)	
≥1	0
0.9-0.4	6
<0.4	11
0	33

On CT angiography, numbers of lesions detected were 157. 97.4% of lesions were either stenotic or occlusive. 3 patients had abdominal aortic aneurysm; 1 patient had lower thoracic and upper abdominal aortic aneurysm as presented in Figure 2.

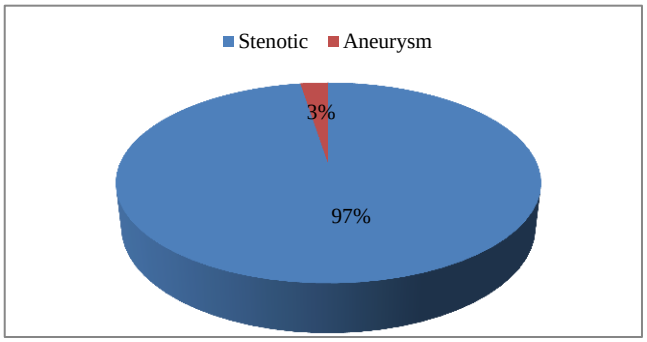

Figure 2: Nature of involvement of atherosclerotic lesions.

Distributions of site of atherosclerotic occlusive lesions in abdominal aorta and in bilateral lower limb vessels were classified and are listed in Table 4.

Maximum number of patients (86%) had femoropopliteal lesions (47.1% of total lesions detected). Aortoiliac lesions were seen in 68% of patients (28% of total lesions detected). 16% of the patients had internal iliac artery lesions (9.5% of the total lesions detected). In this study, the type of collaterals found in respect with the site and type of occlusion are presented in Table 5. Most common type of collaterals (53.4%) is from muscular branches of deep femoral arteries in response to femoro-popliteal

occlusion. 10 patients had collaterals from bilateral DFA. 14 Winslow pathways were found in 10 patients, among them 4 patients had bilateral Winslow pathways. 1 patient had collaterals from bilateral popliteal arteries.

Table 4: Distributions of significant atherosclerotic lesions.

Site of involvement	Number of patients	Number of lesions
Aortoiliac lesions	34	44
Femoro popliteal lesions	43	74
Combined aortoiliac and femoro popliteal lesions	23	23
Bilateral limb vessel involvement (symmetrical/ asymmetrical)	30	30
Renal arteries (unilateral/bilateral)	4	7
Coeliac axis & its branches	5	5
Superior mesentric artery (SMA)	8	8
Inferior mesentric artery (IMA)	4	4
Internal iliac arteries (unilateral/ bilateral)	8	15

Table 5: Collateral vessels in aortoiliac and femoropopliteal PAOD.

Collateral vessels	Number of collaterals	Number of patients	Common sites of occlusion
Winslow pathway (unilateral/bilateral)	14	10	-infra renal aortic occlusion -common or external iliac artery occlusion
Arcade of Riolan	4	4	Coeliac trunk or SMA or IMA occlusion
Collaterals from deep femoral artery (DFA) (unilateral/bilateral)	31	21	Superficial femoral artery (SFA)
Collaterals from internal iliac artery	2	2	Common femoral artery (CFA) (and/or) external iliac artery occlusion
Collaterals arising proximal to the occlusion point	7	7	-Popliteal artery occlusion -SFA narrowing/occlusion

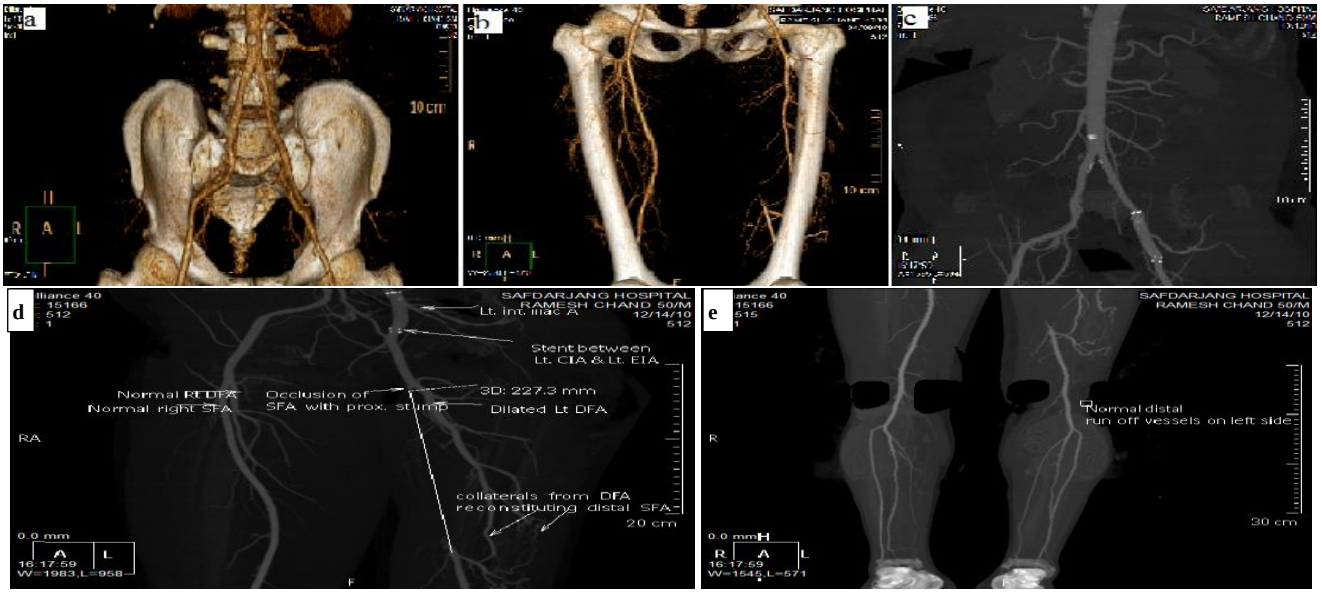

Figure 3: 50 year old male presented with left lower limb claudication with pain free walking distance of <200 meters (stage IIb PAOD). 3a) shows single short segment stenosis (<3 cm) of left external iliac artery (TASC type Aaortoiliac lesion) with post stenotic dilatation. Abdominal aorta and its branches were normal in this patient. 3b) shows total occlusion of left superficial femoral artery of > 20 cm (TASC type D femoro popliteal lesion) with reconstitution of popliteal artery by the collaterals from dilated ipsilateral DFA. 3c & 3d) shows post stenting CT angiography images in MIP reconstruction. 3e) shows normal run off in leg vessels.

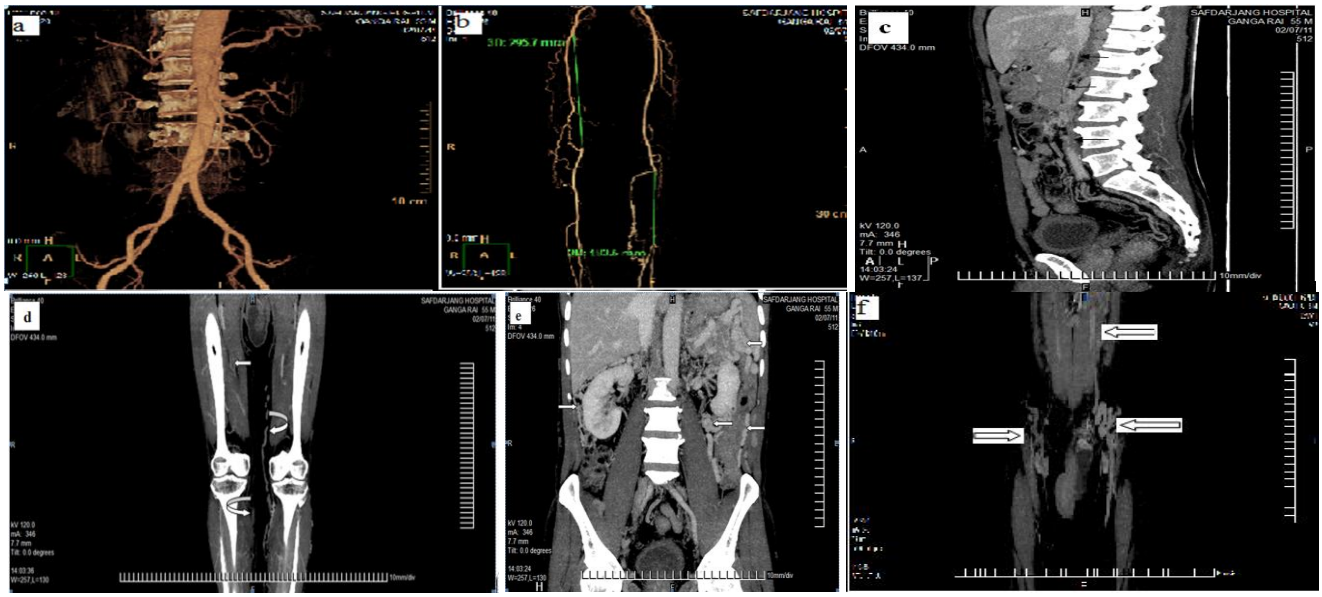

Figure 4: 55 year old male presenting with non-healing ulcer in the plantar aspect of left foot; 4a & 4b: shows normal aortoiliac vessels, right SFA occlusion and left femoro-popliteal occlusion; 4c: shows thrombosis and occlusion of infra hepatic part of IVC (black arrows); 4d: shows deep vein thrombosis of lower limbs (straight arrow) with varicose veins (curved arrows): 4e: shows multiple intra abdominal venous collaterals (arrows) in response to IVC obstruction; 4f: shows (coronal MIP image) parietal wall venous collaterals connecting lower limb veins to upper limb veins, in response to IVC obstruction.

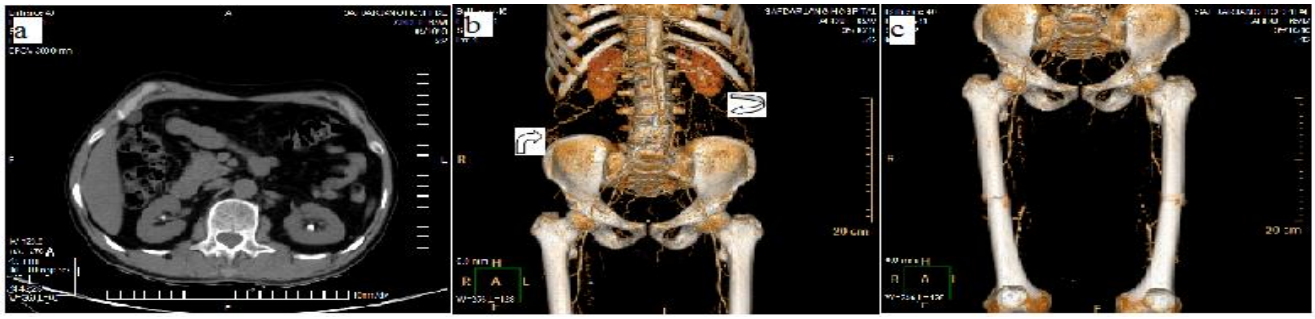

Figure 5: 65 year male presented with gangrene of bilateral toes. Plain CT image in axial section; 5a: show bilateral renal calculi; 5b: shows aortobiiliac occlusion with reconstitution of bilateral distal EIA by inferior epigastric and deep circumflex iliac arteries (curved arrows); 5c: shows long segment occlusion of bilateral SFA with reconstitution of distal SFA by the collateral vessels from dilated DFA of both sides. Distal run off vessels in leg (ATA, PTA, peroneal artery & DPA) were normal in these patients.

Table 6 shows the other vascular pathologies and findings in other organ systems. Out of 50, 11 patients had shown associated lesions with other vascular findings.

Table 6: Vascular findings and status of surrounding organ systems.

Findings	Number of associated lesions
Inferior vena cava(IVC) & deep vein thrombosis of lower limbs	1
Inguinal hernia	2
Renal calculi	5
Prostatomegaly	3

The CT angiographic findings of all the patients with atherosclerotic PAOD were classified individually according to the TASC II as the management strategies were based on this classification. Table 7 presents the TASC II classification of aortoiliac lesions and femoropopliteal lesions. Out of 50, 40 patients who had undergone CT angiography had been followed up. 10 patients were lost to follow up.

The treatments done for these patients are listed in Table 8 as given below. The correct treatment had been made in 32 cases. Among them, 8 patients were managed conservatively.

Table 7: TASC II classification of aortoiliac and femoropopliteal lesions.

Type of lesions	Number of observations
Aortoiliac lesion	
A	9
B	22
C	1
D	12
Femoropopliteal lesion	
A	2
B	32
C	5
D	35

Table 8: Type of management decided after CT angiography among follow-up patients.

Treatment decision	Number of patients
Endovascular procedure	15
Surgery	11
Combined procedure	6
Conservative	8

DISCUSSION

The present study was done to evaluate the role of CT angiography in PAOD patients for assessing the correct management of the same. There is striking increase in both the incidence and prevalence of peripheral arterial disease with increasing age. The prevalence of intermittent claudication would appear to increase from about 3% in patients aged 40 to 6% in patients aged 60 years.[8] In present study maximum number of patients (44%) belonged to 7th decade, followed by those in the 6th decade (24%). Present study shows that, the prevalence is increasing with increase in age till 70years. This is in correlation with the literature quoted above. The prevalence is lowest in the 70-79 age groups in present study. This could be due to low sample size in present study.

In our study the majority (86%) were male patients with a male patient to female patient ratio of 6:1. This is in correlation with the research studies done by Krishnasamy et al in India, stated that, the prevalence of PAOD is more in males compared to females with male: female ratio of 4:1.[11]

Regarding the clinical presentation of PAOD, Creager et al reported that, the most common symptom of PAOD is intermittent claudication (stage II of Fontaine's classification).[2] In contrast to the western literature described above, majority of patients (58% of the patients) in our study presented in the end stage of the disease (stage IV). The reason may be due to the poor socio economic background in most of our patients. Intermittent claudication was the presentation in only 15 (30%) patients in our study

Risk factors associated with PAOD were analysed in our study and compared with the available literatures. Dieter et al quoted that, tobacco smoking is closely linked to PAOD which is 3 times more prevalent in smokers.[12] In our patients smoking and dyslipidemia were the main risk factors; of which chronic smoking was seen in up to 90% individuals; dyslipidemia in 22% of patients. 23 (46%) patients had more than one risk factors of PAOD.

Atherosclerosis is a diffuse process. So, there is considerable overlap between cerebral, coronary, and peripheral atherosclerotic disease. Creager et al stated that, patients with PAOD have a 5-year mortality rate of 15–30% and a 2-6 fold increased risk of death from coronary heart disease.[2] In our study 24% of patients had documentary evidence of ischemic heart disease and a 3 patients of them had triple vessel diseases with subsequent bypass procedures.

Clinical assessment for the presence of and severity of PAOD can be done by measuring the ABI. Norgren et al reported that, measuring the pressure in the ankle arteries has become a standard part of the initial evaluation of patients with suspected PAOD.[8] Our study revealed that maximum number of patients had the ABI value of <0.4 or zero and these findings are well correlating with the end stage clinical presentation.

In present study majority of the lesions (97.4 % of the total lesions detected) were either stenotic/occlusive. Aortic aneurysm was seen in 8% of the patients (2.4% of total lesions detected). This correlates with the study described by Barba et al in which the prevalence of abdominal aortic aneurysms (AAA) in 1166 patients with PAOD was 13% detected by ultrasound and AAA was more prevalent in men than in women.[13]

Mesenteric arterial involvement of the atherosclerotic stenotic or occlusive lesions was also analysed in our study. Cognet et al stated that, it has been suggested that involvement of at least two vessels should be required for a diagnosis of chronic mesenteric ischemia.[14] In present study majority of the stenotic/occlusive lesions had collateral vessels for the reconstitution of arterial tree distal to the level of occlusion. Yapici et al reported that, patients with occlusion at the aortoiliac level have internal thoracic artery (ITA) collaterals to the superior and inferior epigastric artery as a source of supply to the iliac artery and described it as the 'Winslow pathway'.[15] In present study 14 Winslow pathways were found in 10 (20%) patients, among them 4 patients had bilateral Winslow pathways. Of them 3 patients already had documentary evidence of CAD. 1 had single vessel CAD and stenting had already been done. Remaining 2 patients were waiting for surgery.

In femoropopliteal occlusion the most common type of collaterals (53.4% of total collaterals documented) found in our study was from the muscular branches of DFA. One patient had left sided short segment common iliac

artery stenosis (TASC type aaortoiliac lesion) and ipsilateral long segment occlusion of superficial femoral artery (TASC type D femoro popliteal lesion) with reconstitution of popliteal artery by the collaterals from dilated ipsilateral DFA as shown in Figure 3. This patient underwent stenting for common iliac artery lesion. After the procedure the patient is doing well even in the presence of ipsilateral SFA occlusion as the popliteal artery was getting adequate inflow through the collateral vessels from ipsilateral DFA. This explains the importance of assessing the collateral pathways in patients with PAOD and the CT angiography is excellent in depicting the collaterals.

Other vascular pathologies (especially venous system pathologies) and findings in other organ systems were also documented in present study. White in his study reported that approximately one third of patients with symptomatic venous thromboembolism manifest pulmonary embolism, whereas two thirds manifest deep vein thrombosis alone.[16]

In present study one patient had inferior vena cava thrombosis and deep venous thrombosis of lower limb along with extensive atherosclerotic occlusive lesions involving bilateral femoropopliteal arterial tree as described in Figure 4. This patient was having extensive parietal wall and visceral venous collaterals in abdomen with bilateral lower limb varicosities secondary to IVC and deep venous thrombosis. This finding in surrounding organ (in this patient venous system) increases the morbidity and mortality in patients with PAOD. As given in Figure 5 renal calculi were seen in 10% of the patients which also increases the morbidity of PAOD patients.

The CT angiographic findings of all the patients in our study were classified individually according to the TASC II as the management strategies were based on this classification.[10] In present study (n=50) 11 class A lesions, 54 class B lesions, 6 class C lesions, and 47 class D lesions were detected. These are in accordance with the findings of Schernthaner et al. After CT angiography, he noted 6 class A lesions, 5 class B lesions, 1 class C lesion, and 10 class D lesions were detected. Two failing grafts also were detected.[5]

40 patients who had undergone CT angiography had been followed up. 10 patients were lost to follow up. Conservative management was done in 8 patients. Among these 8 patients, 6 had occlusion of distal popliteal artery extending into the trifurcation vessels (anterior tibial, posterior tibial and peroneal arteries), which are the distal run-off vessels. So, they were not fit for either endovascular procedure or the open surgical procedure. Two patients had type B aortoiliac and femoropopliteal lesions and they were responding to medical management alone.

CONCLUSION

CT angiography is useful not only in detecting the primary disease in aortoiliac and femoropopliteal arteries with respect to number of sites involved, number of lesions and the nature of involvement; but also shows collateral pathways, status of mesenteric vessels and the surrounding organs like kidney. It also helps in deciding treatment options according to TASC II guidelines.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Gaziano PA, Gaziano JM. Epidemiology of Cardiovascular Disease. In: Fauci, Longo, editors. Harrison's Principles of Internal Medicine. Volume 2. 17th ed. USA:The McGraw-Hill Companies. 2008:1375.
2. Creager MA, Loscalzo J. Vascular diseases of the extremities. In: Fauci, Longo, editors. Harrison's Principles of Internal Medicine. Volume 217th ed. USA: The McGraw-Hill Companies. 2008:1568-9.
3. Thomas CS, Varghese K, Habib F, Abrahim MT, Hayat NJ, Cherian G. Extent and severity of atherosclerotic vascular disease in patients undergoing coronary angiography - the Kuwait Vascular Study. Angiology. 2003;54:85-92.
4. Creager MA, Libby P. Peripheral Arterial Diseases. In: Libby P, Bonow RO, Mann DL, ZipesDP, editors. Braunwald's Heart Disease. 8th ed. Philadelphia (PA): Saunders Elsevier. 2008:1491.
5. Schernthaner R, Fleischmann D, Stadler A, Schernthaner M, Lammer J, Loewe C. Value of MDCT Angiography in Developing Treatment Strategies for Critical Limb Ischemia. AJR. 2009;192:1416-24.
6. Tins B, Oxtoby J, Patel S. Comparison of CT angiography with conventional arterial angiography in aortoiliac occlusive disease. Br J Radiol. 2001;74:219-25.
7. chernthaner R, Fleischmann D, Lomoschitz F, Stadler A, Lammer J, Loewe C. Effect of MDCT Angiographic Findings on the Management of Intermittent Claudication. AJR. 2007;189:1215-22.
8. Norgren L, Hiatt WR, Dormandy JA, Nehler MR, Harris KA, Fowkes FGR. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). J Vasc Surg. 2007;45:5-67.
9. Fontaine R, Kim M, Kieny R. Surgical treatment of peripheral circulation disorders [in German] HelvChirActa. 1954;21(5):499-533.
10. Dormandy JA, Rutherford RB. Management of peripheral arterial disease (PAD). TASC Working Group. TransAtlantic Inter-Society Consensus (TASC). J Vasc Surg. 2000;31(1):1-296.

11. Krishnaswamy B, Raja N, Deepa S. A study of peripheral vascular disease in elderly and its association with coronary artery disease. J Indian AcadGeriatr. 2006;2(1):10-3.
12. Dieter RS, Chu WW, Pacanowski JP,Mc Bride PE, Tanke TE. The Significance of Lower Extremity Peripheral Arterial Disease. ClinCardiol. 2002;25:3-10.
13. Barba A, EstalloL, Rodríguez L, Baquer M, Vega de Céniga M. Detection of Abdominal Aortic Aneurysm in Patients with Peripheral Artery Disease. Eur J VascEndovasc Surg. 2005;30:504-8.
14. Cognet F, Salem DB, Dranssart M, Cercueil JP, Weiller M, Tatou E, et al. Chronic Mesenteric Ischemia: Imaging and Percutaneous Treatment. RadioGraphics. 2002;22:863-80.
15. Yapici F, Tuygun AG, Tarhan IA, Yilmaz M, Tuygun AK, Yapici N, et al. Limb Ischemia Due to Use of Internal Thoracic Artery in Coronary Bypass. Asian CardiovascThorac Ann. 2002;10:254-5.
16. White RH. The Epidemiology of Venous Thromboembolism. Circulation. 2003;107:4-8.

Cite this article as: Kumar UK, Grover SB, Jain SK, Bansal S, Prasad J, Thukral BB. Evaluation of peripheral arterial occlusive disease by computed tomography angiography. Int J Res Med Sci 2016;4: 4675-82.