Comparison between Computed Tomography Angiography and Digital Subtraction Angiography in Critical Lower Limb Ischemia

Hesham Ebrahim Ahmed Al-rudaini1, Ping Han1,* and Huimin Liang1

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Abstract: Background: CT Angiography (CTA) of aortoiliac and lower extremity arteries is a relatively recent innovation of CT imaging that has changed after the introduction of multi-detector row scanners

Objective: The study aimed to evaluate the diagnostic accuracy of Multidetector Computed Tomographic Angiography (MDCTA) in the assessment of arterial tree in patients with Peripheral Arterial Occlusive Disease (PAOD), as compared to Digital Subtraction Angiography (DSA).

Methods: A single-center nonrandomized prospective study was conducted on 50 patients complaining of peripheral arterial disease (chronic stage) from February 2017 to October 2017. All the patients were exposed to DSA and CTA prior to definitive treatment. The images were then analyzed using maximum intensity projection, volume-rendered, and curved multiplane reformation techniques.

Results: All the patients involved in this study were susceptible according to their clinical presentation. The statistical analysis exposed a highly significant difference between CTA and DSA in the assessment of stenosis at the level of Femoropopliteal segment (P<0.01), while for infrapopliteal segment, there was no statistically significant difference between CTA and DSA having 8% versus 14% insignificant stenosis and 62% versus 47% significant stenosis in CTA and DSA, respectively. The overall accuracy of CT angiography in the femoropopliteal segments was 95.20% while in the infrapopliteal segment it was 94.5%.

Conclusion: Multidetector CT angiography was found to be a reliable alternative mean for pathoanatomical description of the arterial lesions in critical lower limb ischemia and its subsequent management in comparison to digital subtraction angiography.

Keywords: Multi-detector computer tomography, lower extremity arteries, peripheral arterial disease, digital subtraction angiography, critical lower limb ischemia, atherosclerosis.

1. INTRODUCTION

Atherosclerosis of lower limbs is a common problem in elderly population. The condition is commenced by cardiovascular risk factors like Diabetes Mellitus (DM), hypertension, dyslipidemia and smoking [1].

Elaboration of disease severity and extent is the mainstay of therapeutic planning in patients with PAOD [2]. In practice, Digital Subtraction Angiography (DSA) has been introduced as a diagnostic and therapeutic measure. However, DSA is an invasive method with considerable complication rate (10%) and necessitates a learning curve to hold a vascular unit [3]. Advanced technology in recent contrast-enhanced magnetic angiography and multidetector angiography machines is rendered necessary only for performing conventional angiography for therapeutic purposes. On the other hand, Magnetic Resonance Angiography (MRA) and CTA are more superior to duplex ultrasonography (US) in the diagnosis of patients with PAOD [4]. CTA is advantageous in comparison to DSA. Widespread availability, easiness, short examination time and cost-effectiveness are all advantages of CTA, hence the former is regarded as a first-line diagnostic procedure in atherosclerotic syndromes. Met and coworkers evaluated 20 prospective randomized controlled studies and 16-MDCT and conventional angiography with a total pool of 957 participants. The crude sensitivity and specificity were 95% and 96%, respectively [5]. Two studies measured the improved performance for MDCT1 and it showed increased sensitivity and specificity (97%-99%, 97%-98%) respectively [6, 7]. In these two studies, small sample size was a limitation. this study aimed to assess the diagnostic preciseness and therapeutic management of multidetector computed tomographic angiography (MDCTA) in the valuation of arte-
rial tree in patients with peripheral arterial occlusive illness (PAOD), with the reference method for elaborating arterial patency; conventional digital subtraction angiography (DSA).

2. RESEARCH METHODS AND DESIGN

We prospectively evaluated the useful impact of 64-MDCT angiography in comparison with DSA in patients with PAOD.

2.1. Patient Population

After obtaining approval from the institutional ethical committee, all participated patients were requested to sign an informed consent. A single-center nonrandomized prospective study was held subsequently from February 2017 to October 2017.

Out of the 56 consecutive patients enrolled in our study, 6 patients were excluded, 2 patients refused study participation, 3 had acute ischemia and one patient was diagnosed with severe renal failure due to renal artery stenosis (Table 1).

The patients’ average age was 62.5 years old and median age was 63 years. 35 patients were male (70%) and 15 patients were female (30%). Most of them had a risk factor. 28 patients had hypertension (56%). Most of the patients were diabetics (90%). The median duration of DM was 19.1 years. 36 patients were smokers (72%). The median smoking duration was 36 years (Table 2).

All patients were classified as critical ischemia patients. Thirteen patients (60%) had rest pain. Nineteen patients had gangrene (38%). Five patients had an ulcer (25%). Twelve patients had a mixed presentation (24%). Seventeen patients had a previous amputation (34%). Fifteen patients were presented with critical limb ischemia on the left side (30%) and only fourteen patients presented with critical limb ischemia on the right side (30%). The mean ankle-brachial index was 0.27 (Table 2).

2.2. 64-MDCT Technique

Computed tomography angiography was commenced prior to digital subtraction angiography in order to prevent study bias. The machine-implemented was of 64-section scanner (Sensation Cardiac 64; Siemens, Forchheim, Germany) and equipped according to the standard protocol. Each patient received iomeron 400 (400 mg of iodine per milliliter, Iomeprol 400; Bracco Imaging, Milan, Italy).

Through a needle gauge (18-20) inserted in the superfical vein in antecubital fossa connected to an automated injector (Stellant; Medrad, Warrendale, Pa) with a constant rate of 4 mL/sec, the contrast material was adjusted for each patient according to the scan duration of 4 mL/sec and body anthropometric indices. In general, scanning time was limited to 33 seconds. The mean of contrast volume was 130 mL.

The saline infusion was preceded at a rate of 4 mL/sec. We used bolus tracking to determine the delay between the administration of contrast media and initiation of scan individually. Attenuation threshold within the required circular domain of 10-15 mm² in the lumen of the proximal abdominal aorta was D200 HU with an 8-seconds delay before scanning. The reconstruction field of vissin was 34 cm, and the matrix size was 512 × 512, producing a voxel size of 0.6 × 0.6 × 0.6 mm³; an average of 5720 transverse images (range, 5160-6225 images) was generated for each patient.

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Medium soft-tissue deconvolution algorithm (B20 kernel) was the software used for image reconstruction. Artifacts from calcified lesions were omitted by using medium-sharp deconvolution filter to decrease blooming artifacts.

Data elaborated from scanning were transferred to a dedication workstation (Aquarius; TeraRecon, San Matteo, Calif) to be processed. Three-dimensional image reconstruction was achieved through maximum intensity projections, volume-rendered images, and curved multiplanar reformations along the longitudinal axis of the artery.

Each patient at the end had a set of 25 images generated with 3D reconstruction algorithms which were prepared for evaluation.

2.3. Digital Subtraction Angiography (DSA)

Conventional digital subtraction angiography was performed by a consultant radiologist and a researcher at standard angiography unit. A vascular sheath was placed in the femoral artery and 5-F pigtail catheter inserted. An iodinated contrast agent (iomeron 300, 300 mg of iodine per milliliter, Iomeron 300; Bracco Imaging) was executed. Initially, aortogram was obtained and following this, the images of pelvic and leg arteries were acquired. Contrast media were inserted at a rate of 10-15 mL/sec with a final volume of 25-35 mL. If patient was in need of endovascular therapeutic intervention, the procedure would be followed in the same period of time.

Table 1. Inclusion and exclusion criteria.

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Patients with clinical criteria of unilateral chronic lower limb ischemia (Fontaine stage IIa–IV)</td>
<td>1 Contraindication to contrast media administration due to fever or nephrology or allergic reactions</td>
</tr>
<tr>
<td>2 Positive ankle-brachial index test</td>
<td>2 Glomerular filtration rate was less than 30 mL/min/1.73 m²</td>
</tr>
<tr>
<td>3 Doppler ultrasonography revealed significant arterial narrowing</td>
<td>3 Acute on top of chronic ischemia that required emergency intervention.</td>
</tr>
<tr>
<td>4 Capability for undergoing CT angiography and DSA</td>
<td>4 Refused enrollment</td>
</tr>
<tr>
<td>5 Patients who agreed subjecting to the procedures</td>
<td>-</td>
</tr>
</tbody>
</table>

Through a needle gauge (18-20) inserted in the superficial vein in antecubital fossa connected to an automated injector (Stellant; Medrad, Warrendale, Pa) with a constant rate of 4 mL/sec, the contrast material was adjusted for each patient according to the scan duration of 4 mL/sec and body anthropometric indices. In general, scanning time was limited to 33 seconds. The mean of contrast volume was 130 mL.

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2.4. Evaluation of the Images and Findings

All DSA and CTA images were analyzed by consultant radiologists. Furthermore, CTA results were obtained by another two different consultant radiologists blinded to DSA and clinical examination data.

All images were analyzed in a dedicated workstation using maximum intensity projection, volume-rendered, and curved multiplane reformation methods to identify composition and morphology of stenosis and plaque.

To analyze images, the arterial vascular system was segmented into 35 splits including infrarenal aorta, internal iliac arteries, common femoral arteries, deep femoral arteries, along with proximal and distal segments of external iliac arteries, superficial femoral arteries, popliteal arteries, tibiofibrular trunks, anterior tibial arteries, peroneal arteries, posterior tibial arteries, dorsalis pedis and plantar arteries with both distal segments of anterior and posterior tibial. The presence and degree of arterial stenosis and aneurysmal dilatation were recorded for each. The severity of disease of each segment (if present) was graded into four grades.

1) No or mild stenosis (49% luminal narrowing)
2) Moderate stenosis (50%-69% luminal narrowing).
3) Severe stenosis (70%-99% luminal narrowing).
4) Occlusion (100% lumen blockage).

Grades 3 & 4 were assumed as clinically significant. If another coexisting arterial stenosis was shown in a single part, the higher one was to be evaluated.

Aneurysmal dilatation is defined as 50% enlargement in the diameter of lumen comparing to proximal healthy segment (grade 1). For calcified and non-calcified segments, a sub-analysis was also done furtherly. Atherosclerotic plaques were regarded as calcified if they had more than 50% calcification of the atheroma. Noncalcified segments were named for a predominant/ total soft component of the atheroma. Eccentric calcifications were analyzed according to this classification into calcified or noncalcified accordingly.

The analysis was also achieved to elaborate the diagnostic performance of CT angiography in the diagnosis of severe stenosis or vascular occlusion in nonsymptomatic legs to omit discrepancy in accuracy in a potentially less involved arterial.

Table 2. Demographic characteristics and clinical presentation of cases.

<table>
<thead>
<tr>
<th>Demographic Characteristics of Cases *</th>
<th>Clinical Presentation of Cases*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of cases = 50</td>
<td>Total no. of cases = 50</td>
</tr>
<tr>
<td>N.</td>
<td>%</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>40-80</td>
</tr>
<tr>
<td>Mean±SD</td>
<td>62.5±13.25</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>35</td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>28</td>
</tr>
<tr>
<td>No</td>
<td>22</td>
</tr>
<tr>
<td><strong>DM</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>45</td>
</tr>
<tr>
<td>No</td>
<td>5</td>
</tr>
<tr>
<td><strong>DM duration (years)</strong></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>7-30.</td>
</tr>
<tr>
<td>Mean±SD</td>
<td>19.1±6.4</td>
</tr>
<tr>
<td><strong>Smoking</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>36</td>
</tr>
<tr>
<td>No</td>
<td>14</td>
</tr>
<tr>
<td><strong>Smoking duration (no= 32)</strong></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>20-50</td>
</tr>
<tr>
<td>Mean±SD</td>
<td>36.5±7.55</td>
</tr>
</tbody>
</table>

*Patient’s information displayed in this table have been obtained from their clinical records.

Table 2. Demographic characteristics and clinical presentation of cases.
2.5. Data Analysis

Computer package SPSS, (version 13.0; SPSS, Chicago, III) was used for statistical analyses. All patients were included in the analysis. The diagnostic performance of CT angiography was specified based on accuracy, sensitivity, specificity, positive and negative predictive values, positive and negative patient, segment, and region ratios by using conventional DSA as the reference standard.

Accuracy was obtained as the sum of patients, segments, or regions that were accurately identified from CT angiographic images divided by the total determinants diagnosed by DSA images. While sensitivity was referred as the total of specifically clinically recognized relevant (70% lumen narrowing) diseased segments or regions portrayed at CT angiography divided by the total of clinically relevant (70% lumen narrowing) diseased segments or regions diagnosed by DSA.

Specif...
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Fig. (1). The comparison between CTA and DSA in the evaluation of significant vs. non-significant stenosis of femoropopliteal segment.

Fig. (2). The comparison between CTA and DSA in the evaluation of significant vs. non-significant stenosis of infrapopliteal segment.

Table 4. Comparison between CT angiography and digital subtraction in the assessment of stenosis severity.

<table>
<thead>
<tr>
<th></th>
<th>CTA</th>
<th>DSA</th>
<th>Chi-square</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N.</td>
<td>%</td>
<td>N.</td>
<td>%</td>
</tr>
<tr>
<td>Femoropopliteal Segment for 50 Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50% stenosis**</td>
<td>17</td>
<td>34</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>50-70 stenosis*</td>
<td>8</td>
<td>16</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>&gt;70% stenosis*</td>
<td>11</td>
<td>22</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Multiple stenosis</td>
<td>12</td>
<td>24</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Total occlusion*</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Infrapopliteal Segment for 50 Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50% stenosis**</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>50-70 stenosis*</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>&gt;70% stenosis*</td>
<td>6</td>
<td>12</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Multiple stenosis</td>
<td>11</td>
<td>22</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Total occlusion*</td>
<td>25</td>
<td>50</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

*Significant stenosis, ** Insignificant stenosis.

4. DISCUSSION

Peripheral arterial illness is correlated with high cardiovascular morbidity and mortality. The prevalence rate increases over age (4.5% at age of 40 years to 15-20% at age of 70 years). Although, only 20-30% of them rendered symptomatic and minor percentage evenly requires surgical procedures [8]. Lesion determination by DSA is more conclusive than CTA, dynamic imaging is likely to show good details, and appropriate occlusion judgment. High-density plaque and wall thrombus affect accurate CTA judgment.

Diagnostic imaging plays a significant role in disease staging and surgical planning. Fraioli et al. (2006) showed the upper hand level of MDCT with elevated specificity and sensitivity for disease extension in comparison to DSA. Those patients who were enrolled were successfully treated conservatively [9].

High selectivity of surgical and medical decision for patients with peripheral arterial disease is totally dependent on precise characteristics of vascular tree anatomy [10].

Many studies evaluated the diagnostic ability of MDCT (four vs. 16-section systems) in patients with intermittent claudication [9]. However, there is a minority of researches giving the CLI a scope [5-7, 11-16].

Historically, MDCT in comparison was under the point of publication with a different number of patients and imaging quality (Huang et al. [17]).

The assessment of the extent, location and severity of vascular deterioration in peripheral arterial disease (PAOD) is very important for planning a better treatment concept. Digital subtraction angiography (DSA) is regarded as a reference method for aortoiliac and lower extremity arteries assessment [18]. The main limitations of DSA are radiation
exposure, patient’s discomfort and invasive nature. Studies suggested DSA replacement with MDCT as an initial tool for diagnosis in patients with CLI [19]. Computed tomography with facilitated angiographic pattern is usually used in PAOD patients. MDCT has the disadvantage of the inability to differentiate between calcium loaded thrombus or high iodine concentration. Therefore, MDCT has limited authority in extensive calcified thrombus (crural) [20]. Arteries and conventional bone removal need time-consuming post-processing. Computed tomography angiography (CTA) permits bones and intraluminal plaques’ removal from angiographic data based on spectral discrimination segregating iodine from calcium, ideally producing a true CTA luminogram [21].

These two diagnostic modalities on the decision making of the physician were examined in our hospital. Although there was no statistically significant difference, however, there was still a change in decision making especially in the infrapopliteal segment (from angioplasty according to CT angiography to conservative treatment according to digital subtraction angiography). This study was conducted on fifty consecutive patients.

Sclerotic lesions in PAOD should be assessed effectively and accurately based on three-dimensionally (3D) reconstructed images. This would make CT angiography more accurate comparable to DSA and preferred in daily practice [22].

Fotiadis et al. (2011) [23] found that three-dimensionally (3D) reconstructed images showed segments with hemodynamically significant disease (stenosis 50%). The overall sensitivity, specificity, and accuracy of MDCT in patients with severe claudication and CLI were 99%, 98% and 98%, respectively. The positive predictive value (PPV) was 97% and the negative predictive value (NPV) was 99%. They reported that MDCT angiography is a useful tool as an endovascular treatment in evaluating patients with severe claudication and CLI and could be reliably used to grade disease severity and plan treatment.

Shareghi et al. (2009) reported a sensitivity of 99% and a specificity of 98% as diagnostic preciseness in detecting grade III and IV lesions [7].

For the femoro-popliteal segments, the overall accuracy was 98% with a sensitivity of 100% and specificity of 99%. Considering peripheral arterial disease in the infrapopliteal segments, the overall accuracy was 98% with a sensitivity of 97% and specificity of 99%. Compared to 49 segments that could not be visualized by DSA, only one segment could not be detected by MDCT.

Their study showed an excellent accuracy of MDCT than DSA, and allowed more visualization of the vascular tree.

Met et al. (2009) reported that the overall sensitivity of CTA for detecting more than 50% stenosis or occlusion was 95% (92%-97%) and specificity was 96% (93%-97%). Computed tomography angiography correctly identified occlusions in 94% of segments, the presence of > 50% stenosis in 86% of segments, and the absence of significant stenosis in 95% of segments [5].

Over staging occurred in only 8% of segments and under staging in 14% showing that CTA is as accurate as DSA modality for evaluation of PAD existence and extent in patients with CLI, and that the diagnostic performance of CTA for patients has been merely assessed thus far as well. More dedicated evaluations of CTA in patients with critical limb ischemia are needed.

Edwards, et al. (2005) evaluated 44 patients with CLI who performed both techniques; sensitivity and specificity to detect a hemodynamically significant lesion (defined as >50%) were 88% and 96%, respectively [24].

Abd-ElGawad et al. (2013), on 100 patients with total segment occlusion found an overall sensitivity and specificity of 99% and 99%, respectively [25]. While, Qenawy et al. (2015) found an overall sensitivity and specificity of 98% and 96% [4]. These studies previously proved aptitude of 64 MDCT in the peripheral lower limbs vasculature.

Kock et al. (2007) reviewed the validity, reliability and major limitations of CTA versus DSA in the evaluation of PAOD.

Kock et al. reported that MDCT is the best non-invasive technique. MDCTA has a diagnostic performance and reproducibility in peripheral arterial disease (PAD) assessment. MDCTA reduces diagnostic costs and provides adequate information for decision making [26].

CT angiography (CTA) is an important and versatile, noninvasive implementation of diagnosis as well as surgical or endovascular interventional planning. CTA also plays a role in the workup of nonischemic etiologies such as vasculitis, aneurysms, and congenital vascular malformations in spite of being most commonly performed in patients with peripheral artery disease or trauma affecting the lower extremities [27, 28].

Too many studies have been published on 4-row MDCT, two studies on 16 MDCT while 64-row MDCT was not included in any study ever. Data extracted from his study showed a sensitivity and specificity for detecting >50% stenosis of 92% and 93% was estimated, respectively [26].

Photoacoustic imaging is also a promising tool as a non-invasive method but still under experimental investigation [29].

In general, reproducibility of CTA gained fair agreement between vascular surgeons and radiologists [30]. For Popliteal artery segments, the stenosis CTA showed was higher than DSA in few studies due to non-selective filling [31].

A few studies provided stratified data on the aortoiliac, femoropopliteal, and crural tract and showed that the accuracy and reproducibility of the crural tract were lower than the aortoiliac and femoropopliteal tracts [3, 31, 32].

MDCT can elaborate fair decision making for good anatomical reconstruction in patients with PAOD. In case of non-significant stenosis; CTA>DSA, CT images are prone to detect overlapped and eccentric lesions.

Pointing terms of cost-effective character, MDCTA was found to be cost-effective in the work-up analysis for PAOD in medical insurance institutes [30, 33].
Optimal diagnostic imaging technique was a feature of MDCT when compared to DSA and MRA if clinical utility and patient outcome were taken into consideration [33].

Arterial wall calcifications mislead physicians, giving false positive results in reading MDCTA. An indication for MDCTA in patients with Fontaine stage IIb intermittent claudication is highly justified.

However, patients with Fontaine stage III/IV, who are likely to have extensive calcifications of the smaller arteries, could be better off undergoing contrast-enhanced magnetic angiography or DSA [1, 25, 30].

The arterial wall calcifications are known to be an obstacle to luminal assessment. About 30-50% of the vascular wall contains calcifications, 10% of them are severely calcified. Risk factors for vascular wall calcifications are diabetes mellitus, cardiac disease and elderly [3, 33].

Infrapopliteal arterial wall calcifications are more with Fontaine stage III/IV than stage II (4). Kau et al. (2011) evaluated the preciseness of dual-energy CT angiography (DE-CTA) maximum intensity projections (MIPs) in PAOD [34]. CTA was requested for 58 patients and analyzed by two dependent radiologists, and DSA serving as a reference point. Aortoiliac and femoropopliteal regions showed very good agreement, but it was moderate in the crural region, slight in pedal arteries and excellent in bypass segments. Accuracy was 88%, 78%, 74%, 55% and 82% for the respective territories and moderate (75%) overall, with good sensitivity (84%) and moderate specificity (67%). Sensitivity and specificity were 82% and 76% in claudicants and 84% and 61% in patients with critical limb ischemia [34].

In patients with tissue loss, CTA showed the lowest diagnostic accuracy. But sensitivity was the same as CLI patients. CTA produced false positive stenosis gradings in the second group [1].

With regard to crural region, both modalities were not statistically different in diabetic patients [5, 7, 26]. In another study, the sensitivity, specificity, and preciseness for all arterial levels were found to be 92%, 91%, and 91%, respectively. Diagnostic preciseness was lower for the infra-popliteal compared to the femoro-popliteal segments and the sensitivity was lower for four compared to 16 MDCT scanners [2].

In general, studies propose the utility of peripheral CT angiography in the evaluation of patients with PVD, thus providing a new non-invasive alternative to DSA.

Computed tomographic (CT) angiography is increasingly used for diagnostic imaging in patients with peripheral arterial disease. The use of multi-detector row technology has resulted in shorter acquisition time, increased volume coverage, lower dose of contrast medium, and improved spatial resolution for assessing small arterial branches.

LIMITATIONS OF THE STUDY

The limitation of this study could be summarized in that all patients covered were DSA patients compared to very limited patients with less severe PAD resulting in a high incidence of clinically relevant disease, an hence increasing the values on both sensitivity and positive predictive value.

CONCLUSION

Our study focuses on the role of 64 MDCT angiography in the diagnosis of critical limb ischemia relative to digital subtraction angiography and its effect on decision making. Our study also showed an underestimation of the occluded lesions in the infrapopliteal segment by CT angiography (occluded lesions diagnosed as multiple stenoses).

There is a change in the decision making by CT angiography and by digital subtraction angiography, but still not statistically significant except the lesions in the peroneal artery.

LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>CTA</td>
<td>CT Angiography</td>
</tr>
<tr>
<td>DM</td>
<td>Diabetes Mellitus</td>
</tr>
<tr>
<td>DSA</td>
<td>Digital Subtraction Angiography</td>
</tr>
<tr>
<td>MDCTA</td>
<td>Multidetector Computed Tomographic Angiography</td>
</tr>
<tr>
<td>PAOD</td>
<td>Peripheral Arterial Occlusive Disease</td>
</tr>
<tr>
<td>US</td>
<td>Ultrasonography</td>
</tr>
</tbody>
</table>

AUTHORS CONTRIBUTIONS

Hesham. E.A. Al-rudaini was the principal investigator and wrote the manuscript. Prof. Ping Han was the supervisor of the study and made conceptual contributions towards the study and participated in manuscript editing. Huimin Liang assisted with critical review of the manuscript and contributed to the results section of the study.

ETHICS APPROVAL AND CONSENT TO PARTICIPE

The study was approved by the ethics committee of Tongji Medical College, P.R. China.

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Written informed consent was obtained from all the participants for this study.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.
ACKNOWLEDGEMENTS

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REFERENCES


