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DIAGNOSTIC ACCURACY OF CT ANGIOGRAPHY FOR INFRAPOPLITEAL LESIONS IN PATIENTS WITH DIABETIC FOOT ULCERS UNDERGOING ENDOVASCULAR REVASCULARIZATION

ACUIDADE DIAGNÓSTICA DA ANGIOGRAFIA POR TC NAS LESÕES INFRAPOPLITELAS DE DOENTES COM PÉ DIABÉTICO SUBMETIDOS A REVASCULARIZAÇÃO ENDOVASCULAR

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Abstract

Background: Computed tomography angiography (CTA) is an accepted technique for selecting patients with peripheral arterial disease for surgical and endovascular treatment. There is limited data regarding its accuracy for infrapopliteal vessels in patients with diabetic foot.
Purpose: Evaluate the diagnostic accuracy of CTA for below the knee arteries in patients with diabetic foot.
Methods: Single-center retrospective analysis of CTA and Digital Subtraction Angiography imaging findings in 14 patients that underwent peripheral arterial revascularization due to diabetic foot ulcers. The sensitivity and specificity of CTA was assessed according to each arterial segment based on an adapted Rutherford Score of disease impairment.
Results: CTA overall sensitivity and specificity for the detection of significant arterial lesions was 1 (95% C.I. 0.89-1) and 0.7 (95% C.I. 0.35-0.93), respectively.
By arterial segment, the sensitivity and specificity for the anterior tibial artery were 0.96 (95% C.I. 0.88-0.99) and 0.86 (95% C.I. 0.57-0.98), for the posterior tibial artery were 0.98 (95% C.I. 0.90-0.99) and 0.93 (95% C.I. 0.66-0.99) and for the peroneal artery were 0.93 (95% C.I. 0.83-0.98) and 0.72 (95% C.I. 0.42-0.92), respectively.
Conclusion: CTA has excellent diagnostic accuracy and allows screening of diabetic patients with infrapopliteal peripheral arterial disease.

Key-words

Diabetic foot; Computed tomography angiography; Endovascular revascularization.

Resumo

Introdução: A angiografia por tomografia computorizada (AngioTC) é aceite como técnica para seleção de doentes com doença arterial periférica candidatos a terapêutica endovascular ou cirúrgica. Não existe suficiente evidencia em relação à sua acuidade em doentes com pé diabético e patologia infrapoplitea.
Objetivo: Avaliar a acuidade diagnóstica da AngioTC nas artérias infrapopliteias em doentes com pé diabético.
Métodos: Estudo unicêntrico retrospetivo dos achados AngioTC e da angiografia digital de subtração em 14 doentes submetidos a revascularização endovascular periférica com pé diabético. A sensibilidade e especificidade da AngioTC foram calculadas para cada segmento arterial de acordo com uma classificação modificada da classificação de Rutherford.
Resultados: A sensibilidade e especificidade global da AngioTC na deteção de lesões estenóticas significativas foi de 1 (95% C.I. 0.89-1) e 0.7 (95% C.I. 0.35-0.93), respetivamente.
Por segmento arterial a sensibilidade e especificidade foram de 0.96 (95% C.I. 0.88-0.99) e 0.86 (95% C.I. 0.57-0.98) na artéria tibial anterior, de 0.98 (95% C.I. 0.90-0.99) e 0.93 (95% C.I. 0.66-0.99) na artéria tibial posterior, de 0.93 (95% C.I. 0.83-0.98) e 0.72 (95% C.I. 0.42-0.92) na artéria peroneal, respetivamente.
Conclusão: A AngioTC tem excelente acuidade diagnóstica e permite a triagem de doentes diabéticos com doença arterial periférica infrapopliteia.

Palavras-chave

Pé Diabético; Angiografia por tomografia computorizada; Revascularização endovascular.

Introduction

Diabetic patients are particularly susceptible to foot infection because of neuropathy, peripheral arterial disease (PAD) and diminished neutrophil function[1]. PAD and infection are the major causes of lower leg amputation in persons with diabetes[2,3]. As a consequence, the incidence of vascular lower limb amputation is eight times higher in diabetic than in nondiabetic individuals[3]. PAD in patients with diabetes has a number of characteristics that renders it more difficult to treat. The atherosclerotic lesions are multilevel and particularly severe in tibial arteries, with a high prevalence of long occlusions[4]. The predilection for multiple crural vessel involvement combined with extensive arterial calcification increases the technical challenges associated with revascularisation, but new techniques and technologies have been introduced for treating PAD, and encouraging results have been reported on endovascular approaches[5,6].

Due to the complexity of PAD in diabetic patients, procedural planning with non-invasive techniques is required. The reported values of sensitivity and specificity for computed tomography angiography (CTA) in identifying significant stenoses and occlusions are in the range of 92–97% and 93–98%, respectively in patients with critical limb ischemia and intermittent claudication[7]. However, there is still limited data in patients with critical limb ischemia, specifically on the tibial arteries of diabetic foot patients[7]. In this study we will assess the diagnostic accuracy of CTA for below the knee arteries in patients with diabetic foot ulcers.

Material and Methods

Inclusion criteria for the study were patients with diabetic foot ulcers eligible for endovascular revascularization. From March to December of 2014 17 patients were screened for this study. Three patients were excluded due to glomerular filtration rate (GFR) < 45 mL/min/1.73m2 and therefore CTA was not performed. Fourteen patents were included in the study. The endovascular treatment of these patients and the resulting diagnostic digital subtraction angiography (DSA) was performed within 15 days after the CTA was performed. Since all fourteen patients had unilateral foot ulcer, selective DSA of the infrapopliteal vessels was only performed in the affected limb, therefore 14 limbs were assessed.

Techniques of CTA and DSA

CTA was performed using a 64-slice MDCT (LightSpeed VCT, GE Healthcare, Waukesha, WI, USA). CTA scans were performed during i.v. administration of 125 mL of non-ionic iodinated contrast medium with a concentration of 320 mg I/mL (Optiray,Mallinckdrot, Saint Louis, USA) by a double barrel injector at a rate of 3.5 mL/s through an 18-gauge i.v. cannula inserted into an antecubital vein. In order to synchronize the scanning with peak arterial opacification, the "smart prep" option of the scanner was used, with a region of interest (ROI) placed on the supraceliac abdominal aorta. Diagnostic selective DSA performed before the endovascular revascularization was employed as the gold standard. Contrast agent injection (Visipaque 270 mgI/mL, GE Healtcare) was performed by an automatic injector (4–10 mL/s according to the level of injection) via 4-6 Fr sheaths or 5 Fr selective diagnostic catheters by either retrograde or antegrade common femoral approach.

Image analysis

Three arterial segments (anterior tibial artery, posterior tibial artery, peroneal artery) were assessed at each limb, for a total of 42 arterial segments. Each segment was blindedly assessed at CTA for the degree of impairment (range, 1–4) following a score (Table 1) modified from a score proposed by Rutherford.

Table 1

Score	Type of lesion
0	No >50% stenosis
1	Single >50% stenosis
2	Multiple >50% stenoses or Single <5 cm occlusion
3	Single >5 cm occlusion or Multiple <5 cm occlusions
4	Multiple >5 cm occlusion or total occlusion

Score for assessment of arterial impairment (modified from Rutherford)

CTA images were analysed at a workstation (Advantage Windows 4.3, GE Healthcare) by one radiologist, with 4 years of experience in interpreting peripheral arterial disease. Assessment of stenoses and occlusions were performed on axial images, maximum intensity projection (MIP) images, volume rendering and multiplanar reconstructions. Stenosis quantification was performed by subjective criteria, with optional use of automatic vessel analysis tools.

DSA images were interpreted by the same radiologist, with 3 years of experience in interpretation of DSA images, 3 months after the CTA and DSA were performed and blinded to the reports in order to avoid measurement bias.

Statistical analysis

Sensitivity and specificity was calculated for overall CTA diagnostic accuracy but also for each of the 3 arterial segments. Receiver operator characteristic (ROC) curves and area under the curve (AUC) were plotted and calculated for each arterial segment.

Results

Twelve patients were male and 2 were female. Mean age was 66.2 (range 56-79). Fourteen limbs for a total of 42 arterial segments were studied by CTA and DSA. The distribution and grade of impairment of the arterial segments in CTA and DSA is shown in tables 2 and 3, respectively.

CTA detected significant lesions (score 1-4) in 35 of the 42 arterial segments while DSA showed that significant lesions were present in 32 of the 42 arterial segments. Therefore, CTA overall sensitivity and specificity for the detection of significant arterial lesions was 1 (95% C.I. 0.89-1) and 0.7 (95% C.I. 0.35-0.93), respectively. Regarding the accuracy of CTA identifying the grade of impairment by arterial segment, the sensitivity and specificity for the anterior tibial artery were 0.96 (95% C.I. 0.88-0.99) and 0.86 (95% C.I. 0.57-0.98), for the posterior tibial artery were 0.98 (95% C.I. 0.90-0.99) and 0.93 (95% C.I. 0.66-0.99) and for the peroneal artery were 0.93 (95% C.I. 0.83-0.98) and 0.72 (95% C.I. 0.42-0.92), respectively.

Table 2 – Distribution and grade of impairment by arterial segment according to CTA

Score	ATA	PTA	PA	Total
0	2	2	3	7
1	0	0	0	0
2	3	1	6	10
3	4	4	3	11
4	5	7	2	14

ATA= Anterior tibial artery; PTA=Posterior tibial artery; PA=peroneal artery

Table 3 – Distribution and grade of impairment by arterial segment according to DSA

Score	ATA	PTA	PA	Total
0	3	2	5	10
1	0	0	0	0
2	3	1	4	8
3	3	3	3	9
4	5	8	2	15

ATA= Anterior tibial artery; PTA=Posterior tibial artery; PA=peroneal artery

ROC curves are represented on figure 1. Calculated AUC for anterior tibial artery, posterior tibial artery and peroneal tibial artery were 0.91, 0.96 and 0.82, respectively.
In 10 revascularization procedures an anterograde puncture of the ipsilateral common femoral was performed, while in the remaining 4 patients a retrograde puncture of the contralateral common artery was performed. A 4 Fr. sheath was used in 11 of the 14 procedures, with a 6 Fr. sheath being used in the remaining 3 procedures.

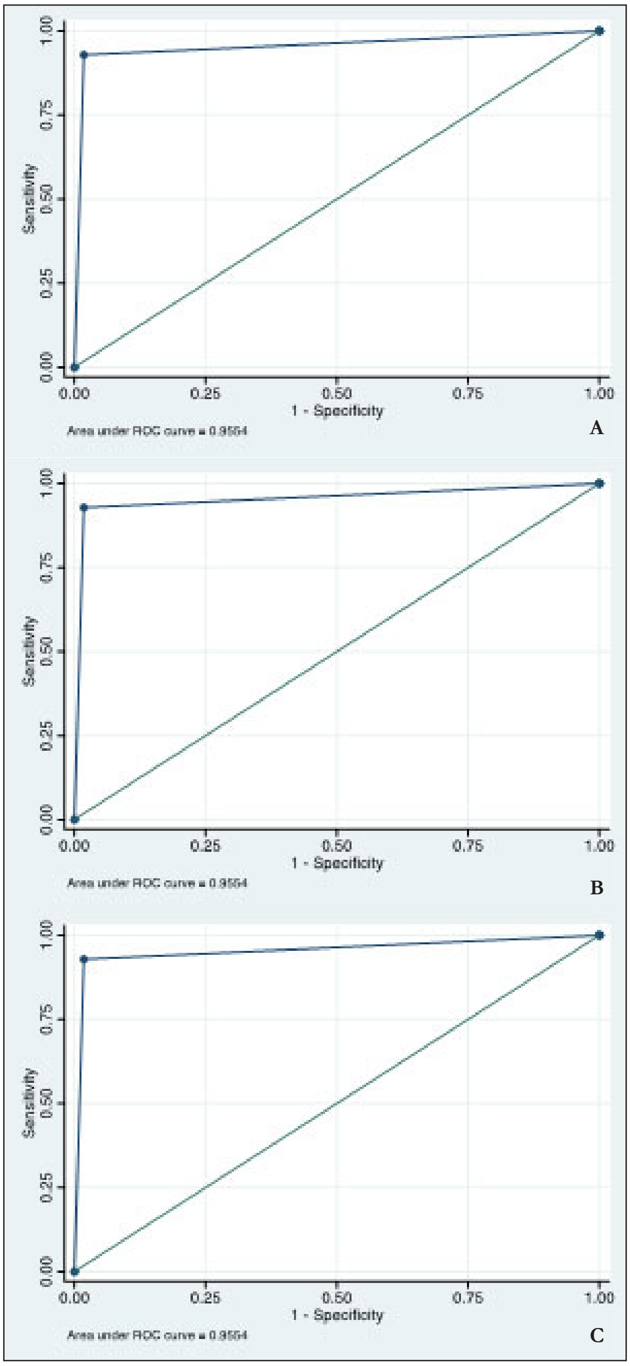

Figure 1 – ROC curves with respective AUC values for anterior tibial artery (A), posterior tibial artery (B) and peroneal artery (C).

Discussion

As new therapeutical tools for lower extremity peripheral arterial disease have been developing, the importance of obtaining high quality images to allow adequate procedure planning is paramount. Knowing the location, severity, and complexity of occlusive disease allows accurate selection of the appropriate approach to revascularization. CTA has the potential to provide a panoramic and accurate vascular mapping[8]. Its advantages compared to DSA include lower cost, its non-invasive nature and lower radiation dose. CTA allows visualization of calcified plaques providing useful data for the endovascular treatment, thus allowing advance selection of the best option for revascularization. Also, the presence of heavily calcified lesions in CTA can predict clinical outcome[9]. Based on the information gathered by CTA, in 10 of the 14 revascularization procedures an anterograde puncture of the ipsilateral common femoral was performed, as CTA clearly indicated the origin of superficial femoral artery was free of stenosis that would deem impossible an ipsilateral approach. In all patients, the decision of the diameter of the sheath was based on CTA, with patients that presented only with lesions of the below the knee vessels (11 of 14 patients) allowing the use of a low profile 4 Fr. sheath. In all patients, the pre-procedural measurement of target vessels on CTA enabled the opportunity to decide the diameter of the angioplasty balloon used in the aid of the catheterization procedure. Balloon diameter ranged between 2-3mm. In 4 patients, due to the presence of heavily calcified lesions on CTA, the choice of guidewire was altered, with specific guidewires with heavier tips being selected in those patients.
In the present study the population consisted entirely of diabetic patients and only the below the knee arteries were evaluated. When evaluating the tibial arteries the sensitivity ranged from 0.96-0.98. These results are slightly higher when compared to pooled results of a recent meta-analysis in which the summary estimate of sensitivity for tibial arteries was 0.95 (95 % CI, 91–97 %)[7]. The sensitivity regarding the peroneal artery was slightly lower at 0.93, and to our knowledge there are no specific values for this segment reported. However, this value is still in the range of 95% C.I. for the overall sensitivity of CTA on the cited meta-analysis 96 % (95 % CI, 93–98 %)[7]. It is the author's opinion that the close proximity of both leg bones may partially explain the lower sensitivity for peroneal artery lesions.
The specificity values reported herein ranged from 0.72 to 0.93, which is lower than previously reported. Meta-analytic data[7] reported a specificity value of 91 % (95 % CI, 60–98 %). This lower specificity is probably related to a selection bias, as our population is constituted entirely by diabetic patients with heavily calcified infrapopliteal arteries. This specific population often presents diffuse concentric calcification in the infrapopliteal vessels. This creates the “blooming” effect of calcium with respect to the vessel’s lumen, making the evaluation of stenosis very difficult[10]. It has been suggested that use of dual source or dual-energy CT can overcome this limitation since it is possible to remove bones and intraluminal calcified plaques from angiography datasets on the basis of spectral differentiation separating iodine from calcium[11]. However, this feature of dual source seems to be limited in below the knee vessels, and thus far no study has shown advantage compared to non-dual-energy technique[8].

Our study was also in line with the expected pattern of lesions in diabetic patients[4]. The most common type of lesion was the most severe type (Score 4) which includes multiple > 5 cm occlusions or total occlusions. Also worth referring is the fact that no Score 1 pattern was found, thus reinforcing the multifocality of lesions in the infrapopliteal vessels of these patients (Figure 2).

Figure 2 – Comparison between CTA and DSA. A. 3D MIP with calcification included B. 3D MIP excluding calcification C. 3D volume rendering D. DSA. Note multiple occlusions of the anterior tibial artery in the proximal segment (straight arrows). Pathology is more severe with total occlusions on the peroneal artery (star) and posterior tibial artery (curved arrows). CTA also depicts a focal occlusion of the proximal segment of the posterior tibial artery (angled arrow).

and non-diabetic patients with CLI candidates to below the knee endovascular revascularization. Also, this study did not evaluate intra and inter observer variability and measurement bias is likely as the same radiologist evaluated both CTA and DSA images. However, there was a 2-month gap between CTA and DSA image interpretation to compensate for potential recall measurement bias.

Our study has some limitations namely the small sample size. It was a retrospective analysis and selection bias was likely as only diabetic foot patients who had indication for endovascular treatment were included. Therefore, our results may not fully apply to the general population of patients suffering from PAD, which includes patients who are candidates for surgery

In conclusion, CTA allows excellent non-invasive diagnostic accuracy for the steno-occlusive involvement of the infrapopliteal segment in diabetic patients with CLI. CTA can be used as the first line investigation tool for diabetic foot patients that are candidates for below the knee revascularization.

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