Diagnostic Efficiency of Low-Dose CT Angiography Compared With Conventional Angiography in Peripheral Arterial Occlusions

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OBJECTIVE. The purpose of this study was to assess the diagnostic efficiency and radiation dose of peripheral arterial CT angiography (CTA) performed at a low tube voltage of 70 kV in comparison with conventional angiography.

SUBJECTS AND METHODS. Thirty consecutive patients (body mass index ≤ 25 kg/m^2) with known or suspected peripheral arterial occlusion diseases underwent both CTA at a low tube voltage of 70 kV and conventional angiography. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of peripheral arterial CTA were evaluated. The radiation dose was recorded.

RESULTS. Diagnostic CTA images were obtained in all patients. CTA allowed accurate identification, characterization, and measurement of all peripheral arterial occlusive diseases. In conventional angiography, 360 diseased segments were found among the 810 segments evaluated. The sensitivity, specificity, PPV, NPV, and accuracy of CTA were 100% (95% CI, 98.81–100%), 93.5% (90.96–95.36%), 90.86% (87.38–93.45%), 100% (99.17–100%), and 96.05% (94.48–97.19%), respectively, with a kappa value of 0.92 (excellent agreement). The mean CT dose index was 3.71 ± 0.8 mGy, and the dose-length product was 446.6 ± 35.7 mGy × cm. The effective dose was 1.94 ± 0.21 mSv for CTA and 4.41 ± 0.64 mSv for conventional angiography.

CONCLUSION. CTA of peripheral arteries with a low tube voltage of 70 kV provides reliable information and serves as a rapidly performed and easily available “one-stop-shop” imaging modality in the diagnosis of peripheral arterial occlusion diseases.

Keywords: arteries, conventional angiography, CT angiography, radiation dose

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Conventional angiography is considered to be the diagnostic standard for peripheral arterial occlusive disease (PAOD). However, because of invasiveness, higher radiation dose, the need for hospitalization, and a low risk of complications (hematomas, dissection, vascular rupture, and death) [1], the diagnostic role of conventional angiography has largely been replaced by other noninvasive imaging modalities [2–5], such as sonography, CT angiography (CTA), and MR angiography (MRA).

The ultrasound modality is operator dependent and the visualization of the infrarenal abdominal aorta and iliac arteries can be limited by bowel gas. For contrast-enhanced MRA, the venous contamination resulting from the long data acquisition time is one of the disadvantages [6, 7]. Moreover, the limited spatial resolution is another disadvantage of contrast-enhanced MRA [8].

Recently, MDCT angiography has been established as a precise method to examine infrarenal abdominal aorta and lower extremity arterial diseases [2–4, 9–11]. However, the wide range from abdomen to feet and the extended length of data acquisition resulted in high radiation exposure and high dose of contrast medium [9]. Radiation exposure has a negative effect on patients’ organa genitalia, and the average risk for radiation-induced cancer in the general population is 5% per sievert. Several studies [9–11] have shown that the CT dose index (CTDI) to patients undergoing such examinations can be as much as 12.2–13.6 mGy (dose-length product [DLP], 1300–1464.7 mGy × cm) with the volume of contrast medium of 100–140 mL or 1.8 mL/kg.

Patients with PAOD undergoing CTA are at risk of contrast-induced nephropathy because many present with impaired renal function [9]. Various strategies to reduce radiation exposure of patients have been developed. Lowering the tube current and tube voltage is the most effective method of radiation dose reduction [12], and automatic current modulation has been widely adopted. Lowering the tube voltage is an important dose-reduction approach because radiation varies with the square of tube voltage. In addition, for IV contrast-enhanced CT, decreasing the tube voltage has been confirmed as a technique to improve contrast visualization because it allows a better match between the effective energy of the x-ray beam and the maximum absorption close to the k-edge of iodine [9]. A low tube voltage of 80 kV has been applied in angiography at a reduced contrast dose compared with standard-voltage CTA. However, increased image noise and decreased signal-to-noise ratio (SNR) are the major disadvantages of the low-tube-voltage technique, especially for heavy patients [13]. In thin patients, the low-tube-voltage technique combined with high tube current–time product reportedly can be used to increase image quality without a radiation dose increase [9, 13, 14].

The low tube voltage of 70 kV is available on a second-generation dual-source CT (DSCT) system. It was developed for pediatric patients [14], but it might be possible to use in adult CTA. To our knowledge, no published studies have evaluated the diagnostic efficiency of 70-kV CTA in patients with peripheral arterial diseases.

Subjects and Methods

This study was approved by our institutional review board. Prior written informed consent was obtained from all patients.

Patients

Between January and July 2012, we evaluated 30 consecutive patients (19 men, 11 women; mean age, 63.4 years; range, 45–83 years) with a known or suspected PAOD, including four endovascular stents in three patients. The patients were referred for lower extremity arterial CTA at 70 kV. The exclusion criteria were presence of renal failure or contraindication to iodinated contrast medium or body mass index (BMI) more than 25 kg/m^2. All patients were confirmed to have PAOD by conventional angiography.

CT Angiography and Contrast Injection Protocols

All CT examinations were performed on a second-generation DSCT scanner (Somatom Definition Flash, Siemens Healthcare). CTA data acquisition was performed in the craniocaudal direction from the level of the renal aorta to the feet.

CT parameters were set as follows: fixed tube voltage of 70 kV; reference tube current–time product, 320 mAs (mean effective tube current–time product, 312 effective mAs; range, 254–357 effective mAs with automatic tube current modulation); rotation time, 0.33 second; collimation, 0.6 mm; pitch, 0.8.

In all patients an iodinated contrast medium (350 mg I/mL) was injected with a double-head power injector via upper veins for a fixed injection time (20 seconds). The volume was 1.2 mL/kg of body weight (on the basis of the previous report by Utsunomiya et al. [9]), followed by a 50-mL saline chaser with the same injection rate. The bolus-tracking technique was used, with a trigger attenuation threshold of 150 HU within the juxtarenal abdominal aorta and a 4-second delay before the start of the acquisition. Study length and scanning time were recorded.

Image Postprocessing and Analysis

Images were reconstructed with a slice thickness of 0.75 mm and increment of 0.5 mm using a medium smooth–tissue convolution kernel (B20f). All images were transferred to an external workstation (Multiple Modality Workplace, Siemens Healthcare) for further analysis. Volume rendering, maximum-intensity-projection, multiplanar reformation, and curved-planar-reformation images were used for image interpretation.

Two radiologists with 6 and 7 years of experience evaluated the data and made the diagnoses. The peripheral arterial CTA images were divided into three anatomic parts: aortoiliac, femoropopliteal, and lower leg. For the comparative analysis of diagnostic efficiency, the arterial system was divided into 27 segments: infrarenal aorta, left and right common iliac arteries, external iliac arteries, internal iliac arteries, common femoral arteries, deep femoral arteries, superficial femoral arteries, popliteal arteries, tibiofibular trunk, anterior tibial arteries, peroneal arteries, posterior tibial arteries, dorsal pedal arteries, and plantar arteries. This resulted in a total of 810 evaluated segments.

A 4-point scale (3, excellent; 2, good; 1, adequate; and 0, poor) was used for grading the overall image quality and artifacts on the basis of a previous study [15]. Diagnostic image quality was established on the basis of CT attenuation (≥ 200 HU) in the three anatomic parts and the 4-point scale.

Patency of the arterial segments was evaluated by using a 5-point scale [15, 16]: 1 = normal, 2 = moderate stenosis (≤ 50% stenosis), 3 = single severe stenosis (> 50% stenosis), 4 = diffuse severe stenosis (> 50% stenosis), and 5 = occlusion. A higher grade of stenosis was assigned if concurrent arterial stenosis happened in a single segment. Sensitivity, specificity, positive and negative predictive values (PPV and NPV), and accuracy of the lesions were calculated for each segment on a per-anatomic-part level separately. The findings of the conventional angiographies were used as the reference standard.

Conventional Angiography

In all 30 patients, intraarterial conventional angiography was performed. For evaluation of the abdominal aorta and iliac arteries, 30–40 mL of nonionic iodinated contrast medium (iopromide, 350 mg I/mL, Ultravist, Bayer HealthCare) was injected. For the lower leg arteries, 60–80 mL of contrast medium was administered. On average, a total of 90–120 mL of contrast medium was injected during conventional angiography.

Radiation Dose

The parameters of radiation dose were obtained from the scanning protocol generated by the CT system after CT. These parameters included the scanning length, CT data acquisition time, CTDI, and DLP. For conventional angiography, the dose-area product was displayed by the fluoroscopy system itself.

The conversion factors for legs are not available, so the effective doses delivered from CTA and conventional angiography were calculated for the region of abdominal aorta and iliac arteries in our study. The conversion factors of 0.015 mSv/mGy × cm [17] for CTA and 0.20 mSv/Gy × cm^2 for conventional angiography [18] were used to convert DLP or dose-area products into effective dose.

Statistical Analysis

Quantitative data were expressed as means ± SD. Statistical analysis was performed with SPSS version 17.0 (SPSS). CIs at 95% for sensitivity, specificity, PPV, NPV, and accuracy were calculated. Interobserver agreement in subjective image quality grading and CT measurements was assessed by the Cohen kappa test [19], and values of 0.61–0.80 corresponded with good agreement and values between 0.81 and 1.00 corresponded with excellent agreement. A p value < 0.05 was considered to be a significant difference; a p value of 0.0125 was used when investigating the diagnostic accuracy among the three anatomic parts.

Results

Diagnostic CTA images were obtained in all patients. CTA allowed accurate identification, characterization, and measurement of all PAOD. The mean attenuation values at the level of the aortoiliac, femoropopliteal, and crural regions were 606.3 ± 94.5 HU, 706.6 ± 102.4 HU, and 794.5 ± 115.6 HU, respectively. The average attenuation value was 702.5 ± 108.8 HU. On the basis of the three anatomic parts, interobserver agreement between the two radiologists in the interpretation of CTA images was excellent (κ = 0.82) for the aorto-iliac tract, and good for the femoropopliteal arteries (κ = 0.75) and the lower leg arteries (κ = 0.63). At consensus reading, the mean scores of the two radiologists were 2.3 ± 0.70 for the aortoiliac, 2.7 ± 0.53 for the femoropopliteal, and 2.5 ± 0.63 for the lower leg. The mean score for the femoropopliteal was significantly higher than that for the aortoiliac (Student *t*, 2.449; $p = 0.021$). There was no significant difference between the aortoiliac and the lower leg (Student *t*, 1.293; $p = 0.206$) or the femoropopliteal and the lower leg (Student *t*, 1.235; $p = 0.227$).

All of the 810 arterial segments imaged were of sufficient quality to diagnose. Four hundred fifty arterial segments were classified as normal using conventional angiography, but only 418 were graded as normal using CTA. The remaining 32 segments were diagnosed as normal using conventional angiography but were considered moderate ($n = 18$) or single severe ($n = 14$) stenosis using CTA.

Using conventional angiography, 360 diseased segments (44.4%) with stenosis or occlusion in 30 patients were found among the 810 evaluated segments: 126 segments with moderate stenosis, 66 segments with single severe stenosis, 122 segments with diffuse severe stenosis, and 46 segments with occlusion (collateral arteries were detected in 21 of them). Using CTA, 392 segments were classified as diseased arteries. Thirty-two segments were overestimated using CTA by one grade, two segments were overestimated by two grades, and eight segments were underestimated by one grade. The degree of stenosis with conventional angiography and CTA in the infrarenal abdominal aorta and lower extremity arteries are summarized in Table 1.

TABLE 1: Assessment of Degree of Stenosis With Conventional Angiography and CT Angiography (CTA)

CTA	Conventional Angiography 1	2	3	4	5	Total
1	418	0	0	0	0	418
2	18	112	2	0	0	132
3	14	12	46	2	0	74
4	0	2	18	118	4	142
5	0	0	0	2	42	44
Total	450	126	66	122	46	810

Note—Data are numbers of arterial segments depicted with both conventional angiography and CTA at 70 kV in the infrarenal abdominal aorta and lower extremity arteries that were evaluated for stenosis.

At consensus reading, the sensitivity, specificity, PPV, NPV, and accuracy of CTA of all 810 arterial segments compared with conventional angiography were 100% (98.81–100%), 93.5% (90.96–95.36%), 90.86% (87.38–93.45%), 100% (99.17–100%), and 96.05% (94.48–97.19%), respectively, with a kappa value of 0.92 (excellent agreement).

The sensitivity, specificity, PPV, NPV, and accuracy of CTA compared with conventional angiography are summarized in Table 2. There was excellent agreement between the two methods for aortoiliac arteries (κ = 0.98), femoropopliteal arteries (κ = 0.93), and runoff arteries (κ = 0.88). Aortoiliac arteries had the highest diagnostic accuracy, and that difference was statistically significant from the diagnostic accuracy for lower leg arteries ($p = 0.004$). There were no differences in the lower leg vessels and the aortoiliac arteries to the femoropopliteal arteries ($p > 0.0125$).

In the aortoiliac tract (210 segments), 116 arterial segments as graded normal on conventional angiography, whereas two of these were graded as moderate ($n = 1$) or single severe ($n = 1$) stenosis using CTA. Ninety-four diseased segments (one endovascular stent in the left external iliac artery included) were considered stenosis or occlusion using conventional angiography: 45 segments were graded as moderate stenosis, five of them were diagnosed as single severe ($n = 4$) or diffuse severe ($n = 1$) stenosis on CTA; 14 segments were graded as single severe stenosis, two of them were diagnosed as moderate ($n = 1$) or diffuse severe ($n = 1$) stenosis on CTA; 32 segments were graded as diffuse severe stenosis on both conventional angiography and CTA; and three occlusive segments were found on both conventional angiography and CTA (Fig. 1).

For femoropopliteal arteries (240 segments), 122 segments were classified as normal using conventional angiography; eight of them were considered moderate ($n = 4$) or single severe ($n = 4$) stenosis using CTA. One hundred eighteen diseased segments were classified as stenosis or occlusion on conventional angiography (three endovascular stents in superficial femoral arteries included) (Fig. 2): 39 segments were graded as moderate stenosis (five of them were diagnosed as single severe stenosis on CTA); 23 segments were graded as single severe stenosis (eight of them were diagnosed as diffuse severe stenosis on CTA); 32 segments were graded as diffuse severe stenosis (two of them were diagnosed as single severe stenosis ($n = 1$) or occlusion ($n = 1$) on CTA); and 24 segments were graded as occlusion (20 of them were diagnosed correctly on CTA and four were diagnosed as diffuse severe stenosis on CTA) (Fig. 3). Collateral arteries were observed in 14 of the 25 patients (Fig. 4).

For the runoff vessels (360 segments), a total of 212 segments were diagnosed as normal by conventional angiography with an overestimation in CTA by one grade in 13 segments and by two grades in nine segments. One hundred forty-eight diseased segments were diagnosed as stenosis or occlusion on conventional angiography: 42 segments were classified as moderate stenosis, the degree of stenosis was overestimated by one grade in three segments and by two grades in one segment on CTA; 29 segments were classified as single severe stenosis, one segment was underestimated by one grade and nine segments were overestimated by one grade on CTA; 58 segments were graded as diffuse severe stenosis, two segments were graded as single sever stenosis ($n = 1$) or occlusion ($n = 1$) on CTA; 19 segments were interpreted as occlusion on both conventional angiography and CTA. Collateral arteries were observed in seven of the 21 patients (Fig. 5).

The mean scanning length and scanning time for CTA were 128.7 cm and 25.3 seconds. The CTDI was 3.71 ± 0.80 mGy, and the mean DLP of the infrarenal abdominal aorta and runoff arteries was 446.6 ± 35.7 mGy × cm. The average DLP delivered in the region of the aortoiliac was 129.5 ± 13.9 mGy × cm, resulting in a mean effective dose of 1.94 ± 0.21 mSv. The mean dose-area products of conventional angiography were 75.96 ± 8.54 Gy × cm^2 for the whole conventional angiography and 22.03 ± 3.17 Gy × cm^2 for the aortoiliac angiography, resulting in an average effective dose of 4.41 ± 0.64 mSv.

Discussion

Our study shows the clinical feasibility of low-tube-voltage CTA of the infrarenal abdominal aorta and runoff arteries at 70 kV

TABLE 2: Results of CT Angiography at Three Anatomic Parts

Characteristic	Aortoiliac	Femoropopliteal	Lower Leg
Sensitivity (%)	100 (96.07–100)	100 (96.8–100)	100 (97.47–100)
Specificity (%)	98.28 (93.93–99.53)	93.44 (87.59–96.64)	89.62 (84.79–93.05)
PPV (%)	97.92 (92.72–99.43)	93.65 (87.97–96.75)	87.06 (81.18–91.3)
NPV (%)	100 (96.74–100)	100 (96.85–100)	100 (98.02–100)
Accuracy (%)	99.05 (96.59–99.74)	96.67 (93.56–98.3)	93.89 (90.92–95.93)

Note—Data in parentheses are 95% CI. PPV = positive predictive value, NPV = negative predictive value.

in thin patients with PAOD. The low-voltage CTA method delivered similar diagnostic capability with less than half of the radiation dose of conventional angiography (1.94 ± 0.21 vs 4.41 ± 0.64 mSv).

With the introduction of MDCT, scanning with thinner collimation and faster data acquisition time, a reduced dose of contrast medium and high diagnostic accuracy were possible [20, 21]. CTA with a lower radiation exposure has been reported to be as good as that of conventional angiography [2–4, 20, 22]; however, the radiation exposure remains the inherent drawback of a CTA modality.

Low-tube-voltage scanning has been suggested as a more effective technique for radiation dose reduction. This technique has an additional advantage of higher attenuation for iodinated contrast agents because the mean photon energy of the conventional beam is closer to the maximum absorption of the k-edge of iodine at 33.2 keV. The mean photon energy in the conventional spectrum is 33.2 keV with 63 kV and 43.7 keV with 80 kV [23]. The low-tube-voltage CT technique increases the conventional absorption of iodine by facilitating photoelectric interactions compared with Compton scattering effects [9, 24–27].

CT at the tube voltage of 120–140 kV was selected as a routine scanning protocol because of good image quality. Recently, lower tube voltage settings at 100 and 80 kV were combined with a higher tube current setting to perform CTA of peripheral arterial diseases [9], aortic diseases [25], and pulmonary arterial diseases [26, 27] in patients with small to medium body weight. A 65% reduction of the radiation dose could be achieved if the tube voltage is reduced from 120 to 80 kV with constant tube current [28]. However, a relatively strong inverse correlation between image quality and BMI has been shown in previous studies [29]. The sinogram-affirmed iterative reconstruction (SAFIRE) algorithm has been confirmed to be beneficial in reconstructing images of the same diagnostic quality acquired with a lower dose compared with the established filtered back projection technique even in heavier patients. The right dose for sound diagnostic imaging in heavier or obese patients needs further study.

A new conventional tube for CT has been developed that allows scanning with a tube voltage of 70 kV. The 70-kV-tube voltage technique was designed to be a more potential contrast medium dose– and radiation dose–saving method for thin patients.

Previous studies have revealed that the attenuation value of iodinated enhancement is increased at a lower tube voltage, resulting in higher enhancement [9, 24–27]. It is reported that the reduction of kilovoltage from 120 to 80 kV allows the reduction of the volume of contrast medium from 1.8 to 1.2 mL/kg without deterioration of vascular enhancement. In our study, 1.2 mL/kg of contrast medium was adopted; however, the arterial attenuation in our 70-kV protocol (702.5 ± 108.8 HU) is higher than that of the previous 80-kV protocol (354.9 ± 61.9 HU) [9]. The higher enhancement using the 70-kV tube voltage protocol was confirmed by our study. The optimum volume, concentration, and injection protocol of peripheral arterial CTA at 70 kV should be explored in a further study.

Wintersperger et al. [30] compared aortoiliac CTA performed at 120 and 100 kV with a constant tube current of 200 mAs; the radiation dose was reduced from 6.7 to 10.1 mSv. For peripheral arterial CTA, Utsunomiya et al. [9] have shown that the reduction of kilovoltage from 120 to 80 kV allows reduction of the radiation dose from 1464.7 to 1024.3 mGy × cm without deterioration of image quality and provides vascular enhancement in the evaluation of the peripheral arteries. Our study shows that aortoiliac CTA performed at a low tube voltage (70 kV) yields diagnostic image quality and high vascular enhancement with an average radiation dose of 1.94 ± 0.21 mSv (4.41 ± 0.64 mSv for conventional angiography).

The disadvantage of the lower tube voltage setting is an increase in image noise. In our study, a reference tube current–time product of 320 mAs with automatic tube current modulation was adopted (180 mAs was used in our previous 120-kV protocol) to compensate for the decrease in the SNR. The mean score for the aortoiliac (2.3 ± 0.70) is a little lower than that for the femoropopliteal (2.5 ± 0.63) and lower leg (2.7 ± 0.53) in our study, but all of the attenuation values of the pelvic arteries were adequate for diagnosis and no statistical differences were found. In our study, 66 diseased segments were overestimated because of vessel wall calcification ($n = 51$), concentric stenosis of noncalcified plaques ($n = 12$), and inappropriate threshold level of 3D volume-rendered images ($n = 3$). A wider window width, higher window center level settings, and sharper reconstruction kernel have been reported to be important for a better differentiation of calcifications from the enhanced lumen and to minimize the effect of blooming. At present, a dual-energy bone and calcification removal imaging modality has been suggested as an effective method to avoid this disadvantage, but the efficacy needs confirmed by a further study. Eight diseased segments were underestimated because of limited spatial resolution.

There are some limitations in the current study. First, the SAFIRE technique is another effective method to decrease the image noise; a further study using the SAFIRE technique and a low kilovoltage setting is required. Second, a relatively small group of patients with peripheral arterial diseases was included; a further study with a larger sample is required. Third, the radiation exposure of our study is significantly lower than that of an 80-kV protocol, but a different CT scanner was used. Therefore, the diagnostic efficiency and radiation exposure should be compared with the same scanner at a standard tube voltage in a further study.

DSCT angiography of the infrarenal abdominal aorta and lower extremity arteries with a low tube voltage of 70 kV provides reliable information and serves as a rapidly performed and easily available "one-stop-shop" imaging modality in the diagnosis of peripheral arterial diseases. Our findings may contribute to the feasibility of low tube voltage at 70 kV in CTA with reduced radiation exposure and increased image quality and diagnostic performance.

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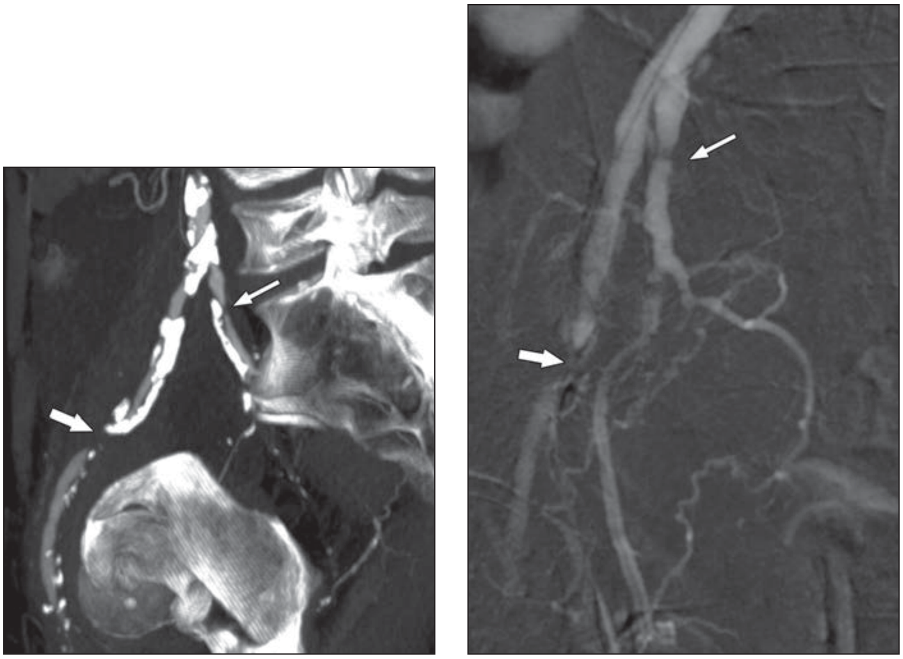
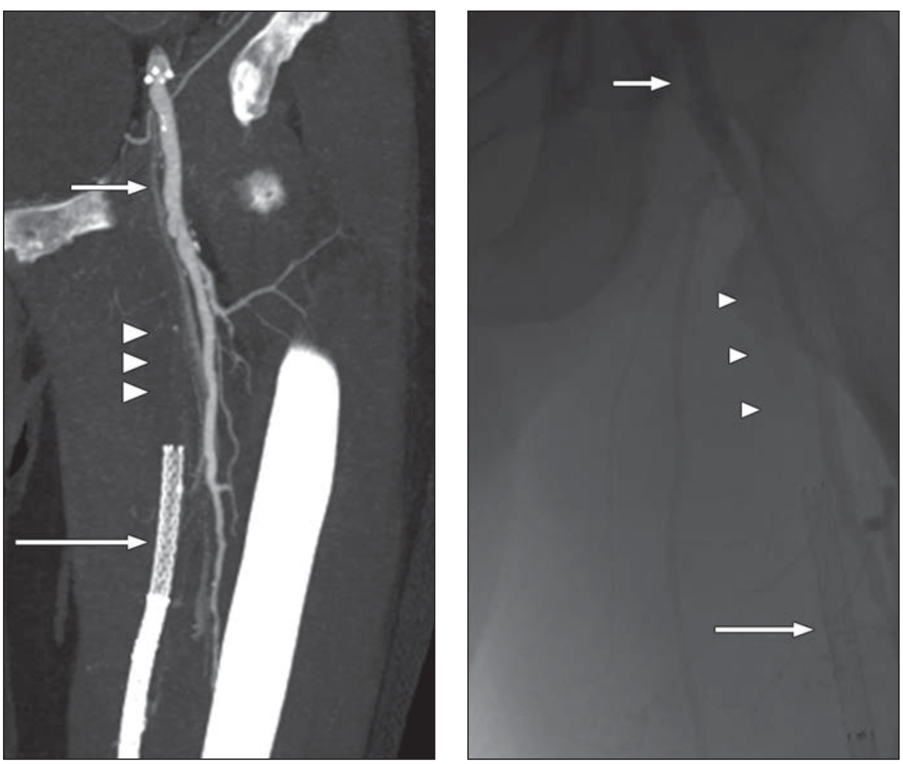
(Figures appear on next page)



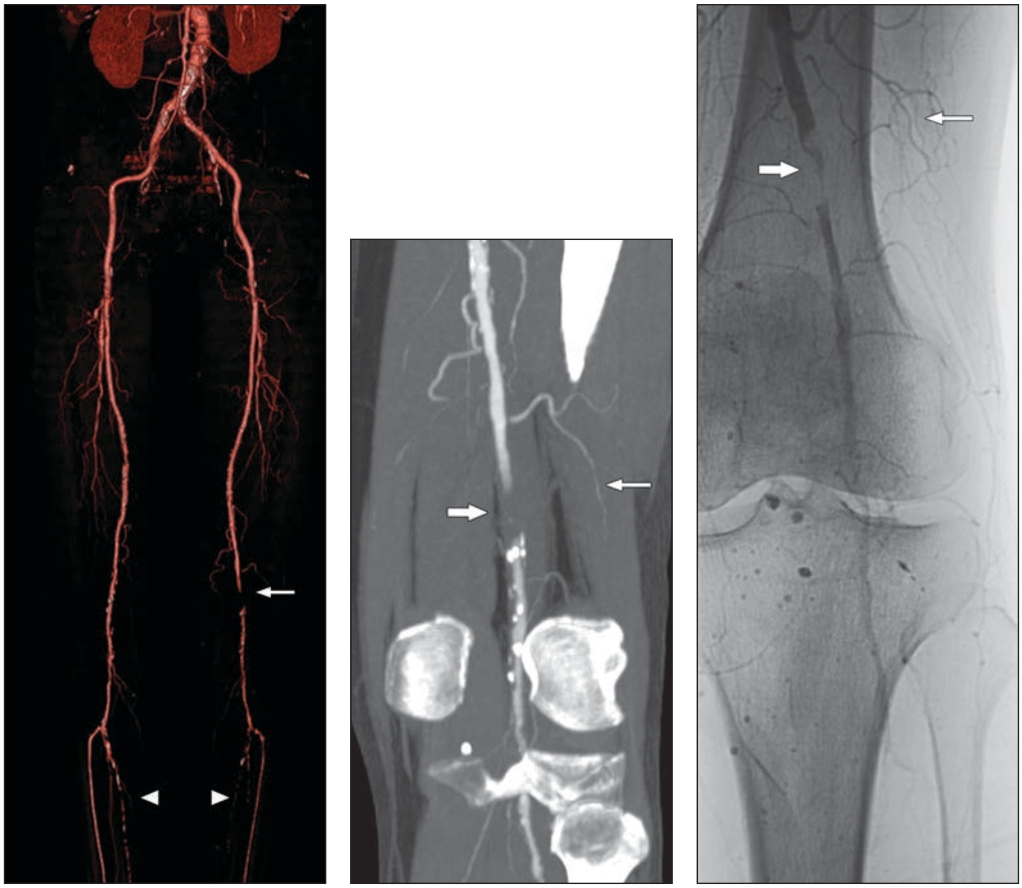
A B

Fig. 1—68-year-old man with peripheral arterial occlusive disease and intermittent claudication of left leg. Dual-source CT angiography was performed at 70 kV and 254 effective mAs/rotation (dose-length product, 398 mGy × cm).
A, Sagittal maximum-intensity-projection image shows diffuse calcification, arterial severe stenosis of left internal iliac artery (*thin arrow*) and occlusion of distal left external iliac artery (*thick arrow*).
B, Conventional angiography image confirms findings of diffuse calcification, arterial severe stenosis of left internal iliac artery (*thin arrow*) and occlusion of distal left external iliac artery (*thick arrow*).



A B

Fig. 2—Images obtained in 67-year-old man with endovascular stent placement in left external iliac arteries and superficial femoral arteries for 1.5 years. Dual-source CT angiography was performed at 70 kV and 318 effective mAs/rotation (dose-length product, 486 mGy × cm).
A, Maximum-intensity-projection image shows endovascular stents present in left external iliac arteries (*short arrow*) and superficial femoral arteries (*long arrow*) and arterial occlusion of proximal superficial femoral arteries (*arrowheads*) was diagnosed.
B,Conventional angiography image confirms these findings of endovascular stents present in left external iliac arteries (*short arrow*) and superficial femoral arteries (*long arrow*) and diagnosis of arterial occlusion of proximal superficial femoral arteries (*arrowheads*).



A B C

Fig. 3—59-year-old man with peripheral arterial occlusive disease and intermittent claudication of left leg. Dual-source CT angiography was performed at 70 kV and 297 effective mAs/rotation (dose-length product, 427 mGy × cm).
A, Coronal volume-rendered image shows diffuse atherosclerosis, severe arterial stenosis of lower leg segments (*arrowheads*), and occlusion of distal left superficial femoral artery (*arrow*).
B, Maximum-intensity-projection image shows occlusive distal left superficial femoral artery (*thick arrow*) and collateral vessel (*thin arrow*).
C, Conventional angiography image confirms findings of occlusive distal left superficial femoral artery (*thick arrow*) and collateral vessel (*thin arrow*).

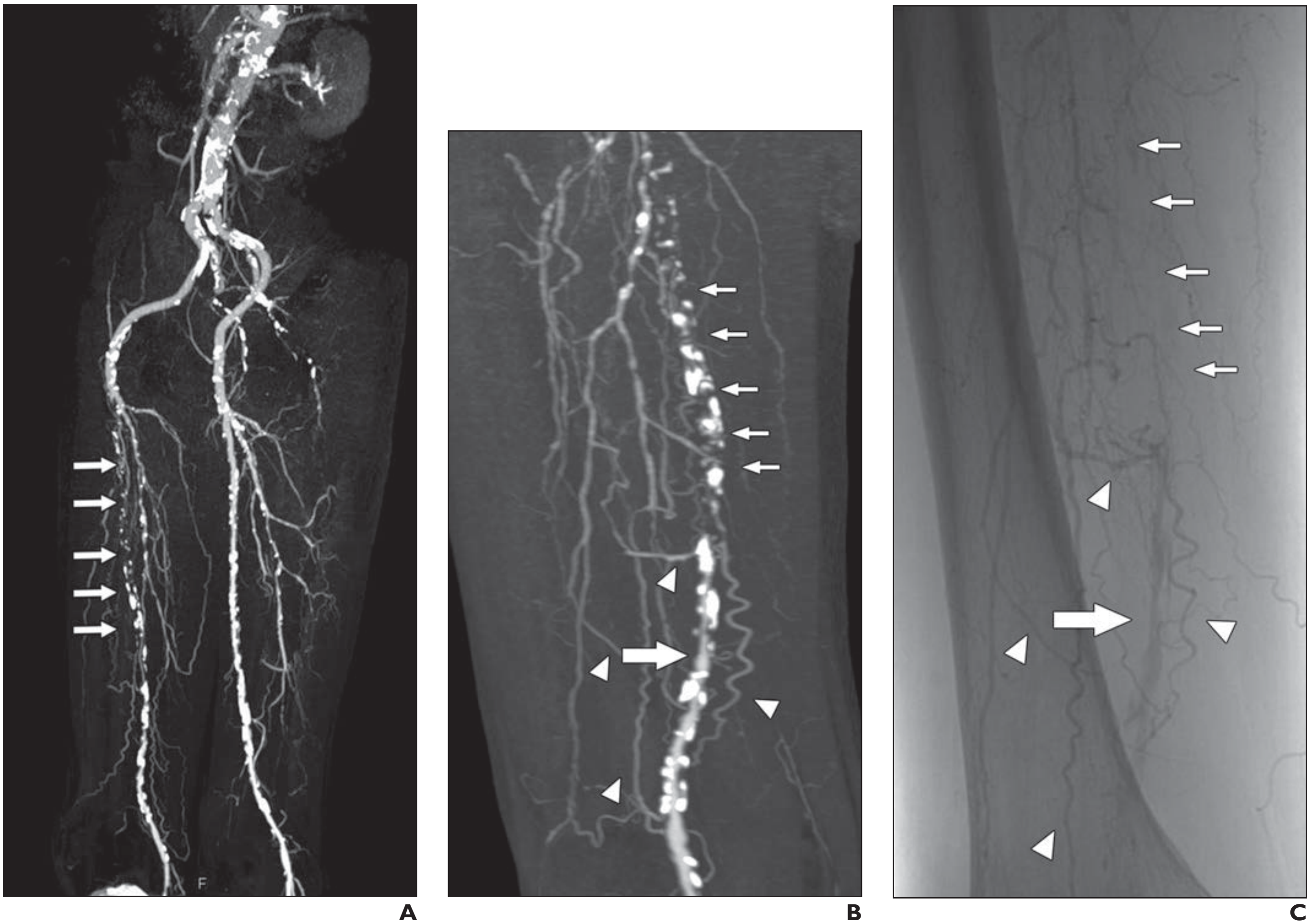


Fig. 4—72-year-old man with peripheral arterial occlusive disease and intermittent claudication of right leg. Dual-source CT angiography was performed at 70 kV and 305 effective mAs/rotation (dose-length product, 466 mGy × cm).
A, Left anterior oblique maximum-intensity-projection (MIP) image shows diffuse atherosclerosis and arterial severe stenosis and occlusion of right superficial femoral artery (*arrows*).
B and **C,** MIP image (**B**) correlates well with conventional angiographic image (**C**) and provides clear depiction of occlusive proximal right superficial femoral artery (*thin arrows*), collateral vessels (*arrowheads*), and distal right superficial femoral artery (*thick arrow*).

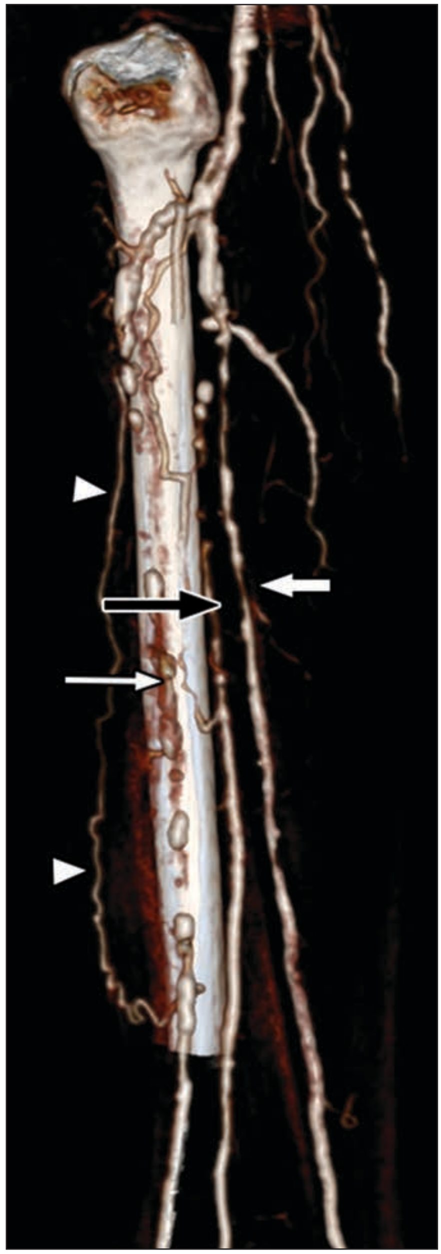


Fig. 5—62-year-old man with peripheral arterial occlusive disease and injury on right foot. Dual-source CT angiography was performed at 70 kV and 253 effective mAs/rotation (dose-length product, 408 mGy × cm). Coronal volume-rendered image shows diffuse atherosclerosis, arterial severe stenosis, and occlusion of anterior tibial artery (*thin white arrow*), peroneal artery (*black arrow*), and posterior tibial artery (*thick white arrow*). Collateral artery is shown clearly (*arrowheads*).