Significance of Anatomical Variability of Tibial and Foot Arteries for Peripheral Angioplasty in Patients with Critical Ischemia

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The authors present a retrospective evaluation of the incidence of atypical anatomical variants of tibial arteries origin and foot blood supply associated with critical ischemia, treated by peripheral angioplasty. Intraprocedural complications caused by atypical anatomy have been taken into consideration.
Keywords: *peripheral angioplasty, critical lower limb ischemia, popliteal artery, anterior tibial artery, posterior tibial artery.*

Purpose of study. This study was aimed at the evaluation of the significance of atypical anatomical variants of popliteal artery branching and foot arteries origin for the performance of peripheral angioplasty in patients with critical lower limb ischemia (CLLI), in whom angioplasty has been used as a primary revascularization method.

Material and methods. In total, 248 peripheral angioplasties (PAP) have been performed in 240 patients with CLLI. The incidence of atypical anatomical variants of popliteal artery branching and foot arteries origin has been studied retrospectively. Clinical results and complications of peripheral angioplasty in patients with typical and atypical branching of the popliteal artery and foot blood supply have been studied.

Results. Atypical branching of the popliteal artery and foot blood supply have been noted in 31 (12,5%) cases (out of 248 legs, on which PAP was performed). Aplasia — hypoplasia of the tibial branches with dorsalis pedis artery (DPA) and/or plantar artery (PlA) arising from the peroneal artery was seen in 17 cases (6,8% of 248 legs, in which PAP has been performed). Herewith only 14 (45%) cases (out of 31 with atypical anatomy) were revealed during diagnostics. In seven (41%) of the remaining 17 cases (non-recognizable before PAP) the peculiarities were suspected only after the occurrence of complications. There were no significant differences between legs preservation rate in the groups with typical and atypical anatomy.

Conclusion. Atypical variants of lower leg and foot blood supply are rather frequent and if not timely recognized can cause specific complications.

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List of abbreviations
CLLI — critical lower limb ischemia
PAP — peripheral angioplasty
PA — popliteal artery
ATA — anterior tibial artery
PTA — posterior tibial artery
PeA — peroneal artery
DPA — dorsalis pedis artery
PlA — plantar artery
TPT — tibioperoneal trunc

Introduction

Endovascular interventions are playing an increasing role in the treatment of critical lower ilmb ischemia (CLLI), expecially in diabetics. In order to achieve clinical success it is necessary to restore antegrade blood flow into the arterial arch of the foot. It often requires recanalization of extended occlusions of the tibial and foot arteries, being the predominant form of arterial lesions in such patients (1, 2).

Besides typical branching of the popliteal artery (PA) below the cleft of the knee into the anterior tibial artery (ATA) and tibioperoneal trunk (TBT) prolonged by the posterior tibial artery (PTA), there are other anatomical variants. They are caused by embryological development and their incidence varies from 7,4% to 17,6% (3, 4). Basing on the results of 1000 legs' angiography, Kim et al. (3) suggested a practical classification of anatomical variants of branching, being a modification of Lippert и Pabst classification (5). The authors suggested three types of anatomical variants that account for the level and the character of branching of the popliteal artery, as well as the origin of the foot arteries. Type I includes the variants with normal level of PA branching, where typical anatomical variant is denominated as IA. Type II comprises the cases with high level of popliteal artery branching above the cleft of the knee, and type III — the cases with aplasia or hypoplasia of the tibial branches with dorsalis pedis artery and/or plantar artery arising from the peroneal artery (Fig.1).

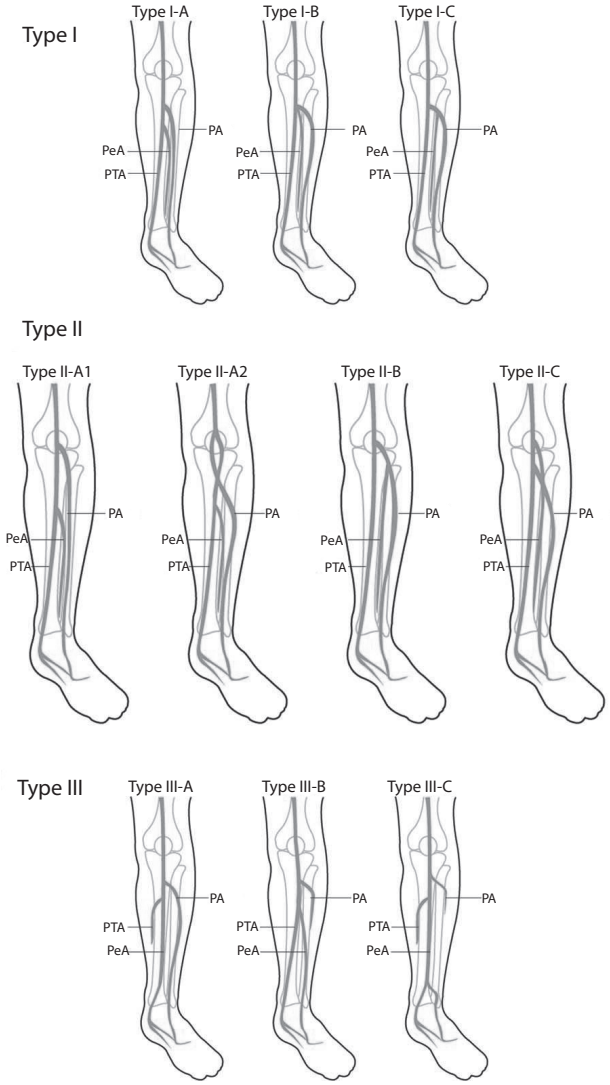

Fig. 1. Scheme of anatomical variants of the PA branching and foot blood supply, suggested by Kim et al.

Type I — normal level of branching: I-A — typical anatomical variant, I-B — trifurcation of the PA, I-C — anterior tibioperoneal trunk, PeA arises from the ATA;

Type II — high branching of the PA: II-A1 and II-A2 — the ATA arises on the level or above of the cleft of the knee, II-B — high origin of the ATA, anterior tibioperoneal trunk, II-C — high origin of the PeA from the PA;

Type III — hypoplasia of the PTA and/or ATA with plantar and/or dorsalis pedis artery arising from the PeA: III-A — hypoplasia of the PTA, the plantar artery arises from the PeA, III-B — hypoplasia of the ATA, the dorsalis pedis artery arises from the PeA, III-C — hypoplasia of the PTA and the ATA, the plantar and the dorsalis pedis arteries arise from the PeA

Abbreviations: PA — popliteal artery; ATA — anterior tibial artery, PTA — posterior tibial artery, PeA — peroneal artery.

The occlusions of the arterial segments in the area of popliteal artery branching, lower leg and foot arteries often complicate the recognition of atypical anatomical variants, which can lead to technical problems and specific complications during endovascular interventions.

The significance of anatomical variability of the PA for various open surgical interventions has been described in the literature (3), however we could not find the works assessing its significance for endovascular interventions. Kawarada et al. (6) reported three clinical cases of successful PAP in type III anatomical variants, with all these variants being evident at diagnostic stage of the intervention (6).

The aim of our study consisted in the evaluation of the significance of anatomical variants of popliteal artery branching and foot arteries origin for PAP performance in patients with CLLI, in whom angioplasty was applied as a primary revascularization method.

Material and methods

From December 2004 through June 2009 in total 248 PAP have been performed in 240 patients with CLLI caused by arterial lesions in femoropopliteal segments, as well as in tibial and foot arteries. Diabetes mellitus was present in 189 (76%) patients. The procedures were performed under local anesthesia, antegrade transfemoral approach was used in most cases. Intraluminal angioplasty was applied for stenoses and non-extended occlusions. In cases of extended (over 5 cm) occlusions in femoropopliteal segment, as well as in crural arteries planned subintimal recanalization and angioplasty according to Bolia technique were used (7, 8).

PAP was considered as technically successful if a continuous antegrade blood flow to the foot was restored in at least one crural artery without >50% residual stenoses. The patients with trophic lesions received necessary local surgical treatment and therapy with antiobiotics. Leg preservation after PAO was determined in accordance with Rutherford recommendations (9).

During retrospective analysis of pre- and post-procedural angiograms, as well as of protocols of procedures we evaluated the incidence of atypical anatomical variants of the origin of tibial arteries and of foot blood supply. Only the cases where the anatomy was univocally interpreted by two experienced interventional radiologists were taken into account. The cases of atypical anatomy were assigned to one of the two groups depending on time of their identification during endovascular intervention. The first group comprised the cases of atypical anatomy that were evident at the stage of preoperative selective angiography. The second group comprised the legs in which atypical variant of PA branching or foot blood supply was identified only during PAP. The intra-PAP complications caused by atypical anatomy and their clinical consequences were taken into consideration.

The preservation of the legs in the groups of patients with typical and atypical anatomy of the PA and foot arteries was determined using Kaplan-Meier method. Parametric and non-parametric statistical techniques were used for the identification of differ-

Table.

Distribution of atypical variants of the PA branching and of the foot blood supply in 248 cases of CLLI when PAP has been performed

TYPE	Cases in total n (%)	Evident before PAP n	Recognized during PAP n	Complications n
Type I				
I-B	3 (1,2%)	2	1	0
I-C	5 (2%)	3	2	1
Type II				
II-A	2 (0,8%)	1	1	0
II-B	4 (1,6%)	2	2	1
Type III				
III-A	8 (2,85%)	3	5	2
III-B	7 (2,82%)	2	5	2
III-C	2 (0,8%)	1	1	1
Total n (%)	31 (12,5%)	14 (45%)	17 (55%)	7 (23%)

ences during group comparison. P value of ≤0,05 was considered as statistically significant.

Results

The incidence of atypical variants of the PA branching and the foot blood supply in the group of study is presented in the Table.

Distribution of atypical variants of the PA branching and of the foot blood supply in 248 cases of CLLI when PAP has been performed

In total, atypical anatomy was noted in 31 cases (12,5%). Aplasia/hypoplasia of the tibial branches with DPA and/or PIA arising from the PeA were noted in 17 (6,8%) cases. Only 14 (45%) cases of atypical anatomy were evident at the stage of preoperative selective angiography. In seven (41%) of the remaining 17 cases (which could not be recognized before PAP) atypical anatomy has been suspected only after the occurrence of specific PAP-related complications. Atypical variants of PA branching were associated with 2 complications related to the search of the ostium of the posterior tibial artery (PTA) in its "typical" location (Fig. 2). In 5 cases with foot blood supply from the PeA system the attempt of recanalization of hypoplastic tibial arteries resulted in their perforation. Clinical consequences have been noted in 1 (20%) of these cases — the perforation of the anterior TA led to hematoma development in the anterior crural muscular bed, which necessitated surgical decompression.

In the group with atypical anatomy technical success was achieved in 28 out of 31 cases (90,3%), while the rate of success in the group of 217 cases without anatomical variants was 93,5% (203 cases). The comparison of these results with the use of exact Fisher's test gave P=0,8. Herewith both groups were similar in age, sex and concomitant pathology. One-year rate of leg preservation was 83,7% for the cases with atypical and 85,9% — for the cases with typical anatomy. The comparison of Kaplan-Meier curves using LogRank Test did not reveal significant difference (P=0.65).

Discussion

According to the data of two large angiographic studies, atypical variants of PA branching and foot blood supply were seen in 7,4% and 17,6% of cases (3, 4). Our results (12,5%) are within these limits. In our opinion, the problem of specific complications caused by atypical anatomy still represents a pressing challenge, despite the absence of significant differences in the rate of technical success and clinical indices in the groups with typical and atypical anathomy.

The incidence of interventions on distal arterial segments during PAP for CLLI is steadily increasing. Most patients in our study had ischemic diabetic foot (76%), and extended occlusions of lower leg arteries is the main type of lesion in such patients. The attempts of intraluminal or subintimal recanalization of a hypoplastic ATA or PTA, at best, will be an exercise in futility, and in the worst will end by perforation and/or occlusion of the artery, with eventual clinical consequences for the patient. The differentiation between an occluded "normal" and hypoplastic tibial artery is not always feasible even in the presence of selective intraoperative angiographic data. In our study only 45% atypical anatomical variants have been recognized before the start of PAP, while in 23% of cases they were revealed only after the development of complications. Most complications (5 out of 7) occurred in the group of patients with type III atypical anatomical variants. In 32% of cases an atypical variant has been suspected on the base of indirect signs, which allowed to change the tactics of intervention and avoid complications. One such case is presented in Fig. 3. If possible, it is necessary to carefully evaluate the blood supply in the other leg, as according to the literature, atypical variants of blood supply in both legs occur in 27,5% — 50% of cases (10, 11).

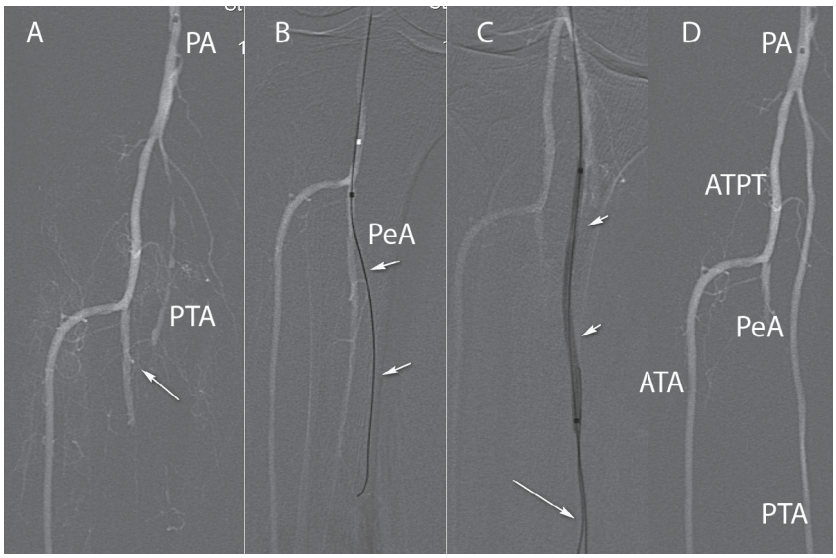

Fig. 2. Angioplasty in high PA branching and anterior tibioperoneal trunk (ATPT).
A *Angiogram of the PA after successful subintimal recanalization of the anterior tibial artery (ATA). The variant of PA branching was erroneously interpreted as typical. Diffusely stenotic and occluded branch of the PA, arising at the level of the cleft of the knee was not recognized as the posterior tibial artery (PTA). The arrow indicates the assumed ostium of the PTA.*
B *The attempts to find the ostium of the posterior tibial artery in its "typical" location led to the perforation with guide (arrows) of a small branch of the peroneal artery (PeA),that had a course similar to this one of a typical PTA;*
C *Subintimal angioplasty of the true PTA was performed. Short arrows indicate the balloon inflated in its lumen in order to facilitate the advancement of a hydrophilic guide' loop (long arrow)*
D *Final result: both tibial arteries are reconstructed. The II-B type is evident.*

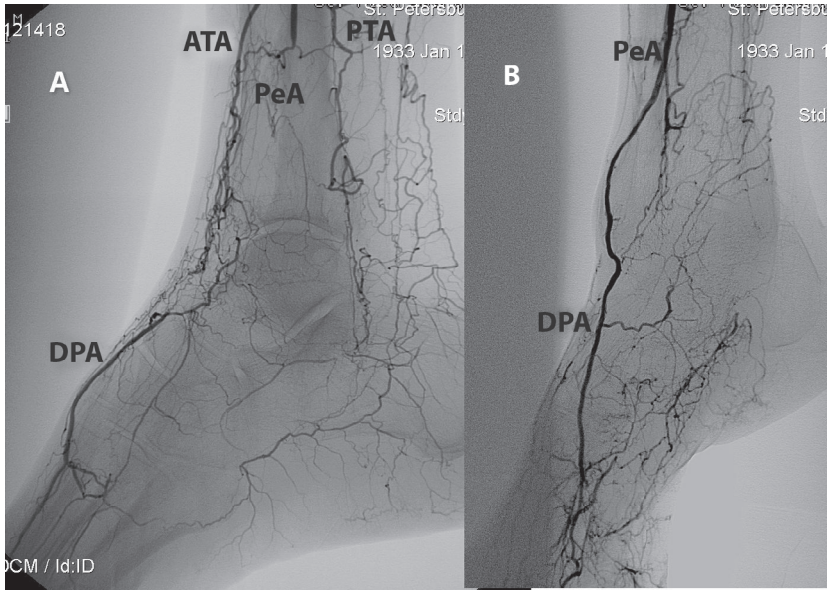

Fig. 3. Dorsalis pedis artery (DPA) arises from the peroneal artery (PeA).
A *Diagnostic stage of intervention: supposed hypoplasia of the anterior tibial artery (ATA), occlusion of the peritoneal artery (PeA) and of the posterior tibial artery (PTA). Large diameter and direct course of the PeA in association with the small tortuous ATA allowed to suppose the DPA origin from the PeA.*
B *Angiograms of final results of PAP: the DPA is a branch of the PeA.*

Maybe, the use of x-ray technique, allowing, unlike contrast angiography, to visualize not only the lumen, but also the course of occluded arteries, for preoperative evaluation of the vascular status will be useful for the recognition of atypical anatomical variants before the procedure. However this approach requires task-oriented studies in patients with CLLI.

We are aware of certain limitations of our study, as it does not take into consideration the cases where even after PAP we could not clearly determine the anatomical variant. It is also probable, that some cases interpreted as foot arteries origin from the peroneal artery, in fact could represent hypertrophied collaterals. However we are sure that our experienced with PAP in patients with atypical anatomy of tibial and foot arteries will be useful for specialists dealing with endovascular treatment of patients with CLLI.

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