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Collateral circulation in distal occlusion of lower limb arteries: an anatomical study and statistical research in 40 elderly subjects by echo-color-doppler method

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SUMMARY

The collateral circles and their hemodynamic significance in distal lower limb arterial occlusion have been described in an elderly population. Overall 40 subjects (20 men and 20 women; age range 66-83) with symptomatic lower limb arteriopathy (Fontaine's stage II) have been studied combining Contrast Angiography and Color Doppler Ecography of the lower limb arterial district.

In our population, the results showed that the tibialis arteries were the vessels most often involved in arterial occlusion (posterior tibialis a., 15 cases = 37.5%, posterior tibialis a., 12 cases = 30%), followed by the peroneal a. (8 cases = 20%) and by the popliteal a. (5 cases, 12.5%). In the occlusion of the popliteal artery the collateral circle was mainly established through the deep femoral a., the great anastomotic a., the recurrent posterior tibialis a., and from the articular supero-lateral a. In the occlusion of the anterior tibialis artery the collateral circulation was ensured through the collateral posterior tibialis as. and through the collateral peroneal as. In the occlusion of the posterior tibialis a., the collateral circle was established through the great anastomotic a., through the branchers of the arterial circle of the ankle and from the perforating plantar as. (anterior tibial a.). Finally, in the occclusion of the peroneal a., the collateral circulation was only represented by branches of the arterial circle of the ankle.

The hemodynamic compromission, measured by the Windsor Index, was the highest for popliteal occlusions (mean IW = 34.38%). Occlusions of the anterior tibialis a. (mean IW. = 35.48%), of the peroneal a. (mean IW = 44.71%), and of the posterior tibialis a. (mean IW = 55.44%) showed progressively lower hemodynamic compromission. Gender differences in hemodynamic significance at each level of occlusion were not significant.

INTRODUCTION

The therapy of lower limb obstructive arteriopathy has been rapidly changin in recent times. Vascular surgery has shown great progress, and several reconstructive techniques are now available to allow an adequate perfusion distal to the stenosis or the occlusion, thus reducing the risk of therapeutical limb amputation (Vollmar, 1967; Cutler and Thompson, 1974; Dale, 1976; Johnson, 1979).

Preoperative analysis of the collateral circulation that has already developed or may be established is necessary for the selection of the optimal surgical treatment. Contrast Angiography (CA) is the gold standard for preoperative investigations; however, in some cases CA alone does not allow correct anatomical identification of the vessels. Combining CA with Color Doppler Ecography (CDE), which simultaneously, displays the vessels and the surrounding anatomical structures, may often overcome this drawback.

Many studies have described the collateral circulation in lower limb ostructions in the living subject by means of CA and in the cadaver using coloured resins (Salmon, 1939; Mercier and Vanneuville, 1968; Renard *et al.*, 1974), while the literature on combined use of CA and CDE is scant. In a previous paper, we have described the collateral circulation in proximal obstruction of the lower limb arteries (ileo femoral district) (Macchi *et al.*, in press). In this study we aim to describe the pattern of distal lower limb arteries obstruction and the collateral circulation in elderly subjects studied by combining CA and CDE.

MATERIALS AND METHODS

The study population included 40 elderly subjects (20 men and 20 women, age range 66-83), with symptomatic lower limb obstruction (Fontaine's stage II) involving the popliteo-tibialis district. Each subject, after giving informed consent, underwent CA of the aorto-iliac and lower limb arteries and CDE of the same districts. Using the doppler technique, it was possible to measure blood flow velocity and pressure distal to the arterial occlusion.

The hemodynamic significance of the collateral circles was assessed by calculating the Windsor index (WI), expressed by the formula: $Wl = (dPx \times 100)/hP$, where: dP = systolic arterial pressure at the anterior or at the posterior tibialis artery, or the average of the two measurements, when both were available; hP = humeral systolic arterial pressure.

For CA, a Philips digital subtraction unit was used, while an Acuson 128XP Echo-Color-Doppler, equipped by 5- and 7MHz probes, was used for CDE. Radiologic, ultrasonographic and hemodynamic data were correlated with age, sex, and body surface area using Student's «T» test.

RESULTS

The results are presented separately for each level of vascular occlusion:

Occlusion of the popliteal a.: 5 cases (*Fig. A*). The collateral circle was mainly established through the deep femoral a. (1), the great anastomotic a. which is collected with the muscular small arterioles originating from the tibio-peroneal trunk (2), from the recurrent posterior tibialias a. (3), from the articular supero-lateral a. (4), from the muscular branches originating from the quadricipital a., and from the popliteal a. itself may give a less important contribution: in this case, the blood flows from the superior articular aa. to the anterior and posterior tibialis as.,

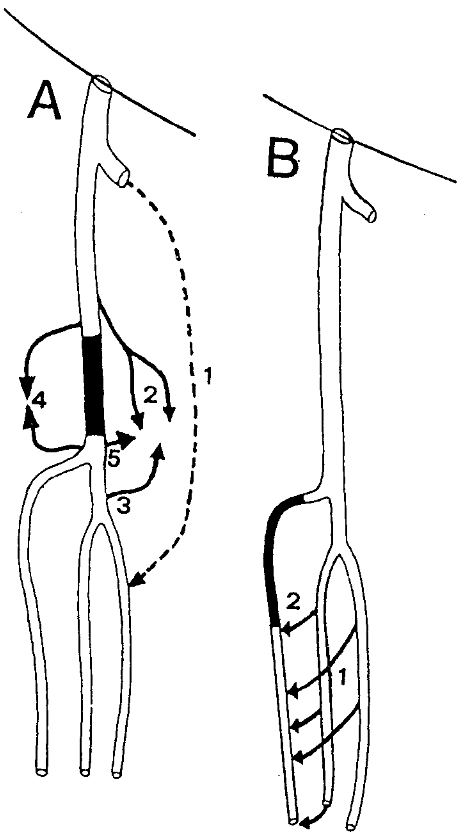

Fig. A. — Occlusion of the popliteal a. Collateral circulation. 1: deep femoral a.; 2: great anastomotic a. - muscular arterioles of tibio-peroneal trunk; 3: recurrent posterior tibialis a.; 4: articular supero-lateral a.; 5: inferior articular as. and recurrent as. of the tibio-peroneal trunk;

Fig. B. — Occlusion of the anterior tibialis a.. Collateral circulation. 1: collateral posterior tibialis a.; 2: collateal peroneal a.

or, less often, from the inferior articular as. and from the recurrent aa. originating from the tibio-peroneal trunk (5).

Occlusion of the anterior tibialis a.: 12 cases (*Fig. B*). The collateral circulation was ensured through the collateral posterior tibialis as. (1) and through the collateral peroneal as. (2).

Occlusion of the posterior tibialis a.: 15 cases (*Fig. C*). The collateral circle was established through the great anastomotic a. (1), through branches of the arterial circle of the ankle (2) and from the perforating plantar as. (anterior tibial a) (3);

Occlusion of the peronal a.: 6 cases (*Fig. D*). The collateral circulation was only represented by branches of the arterial circle of the ankle (1).

The hemodynamic significance, measured by the IW, was the highest for popliteal occlusions (mean IW = 34.38). Occlusions of the anterior tibialis a. (mean IW = 35.48), of the peroneal a. (mean IW = 44.71), and of the posterior tibialis a. (mean IW = 55.44) showed progressively lower hemodynamic compromission.

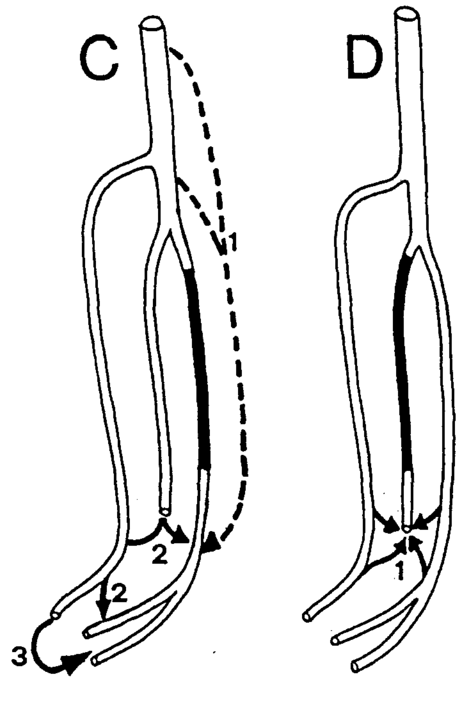

Fig. C. — Occlusion of the posterior tibialis a. Collateral circulation. 1: great anastomotic a.; 2: arterial circle of the ankle; 3: perforating plantar as. (tibialis ant.).

Fig. D. — Occlusion of the peroneal a. Collateral circulation. 1: branches of the arterial circle of the ankle.

TABLE 1								
	sex	age	weight	height	level o.	side	I.W.(%)	BSA (m^2)
1	M	66	70	170	poplit.	DX	52,2	1,81
2	M	66	57	163	post.t.	DX	69	1,61
3	M	66	73	182	post.t.	SN	70,6	1,94
4	M	67	76	178	peron.	DX	32,2	1,94
5	M	67	66	165	ant.t.	DX	34	1,73
6	M	68	79	183	ant.t.	DX	23,3	2,01
7	M	69	77	175	post.t.	SN	56	1,92
8	M	69	72	175	post.t.	DX	70,2	1,87
9	M	70	75	177	ant.t.	SN	44,3	1,92
10	M	71	76	177	post.t.	DX	59	1,93
11	M	73	79	179	post.t.	SN	48	1,98
12	M	74	75	173	peron.	SN	23	1,89
13	M	75	70	159	ant.t.	SN	18,5	1,72
14	M	76	80	178	post.t.	DX	59	1,98
15	M	76	82	181	post.t.	DX	60	2,03
16	M	77	76	173	post.t.	SN	44,4	1,90
17	M	77	64	163	poplit.	DX	29,3	1,69
18	M	78	79	178	ant.t.	SN	45	1,97
19	M	78	58	166	peron.	SN	44,3	1,64
20	M	78	60	158	peron.	DX	65	1,61
21	F	66	76	176	ant.t.	SN	58	1,92
22	F	66	82	174	peron.	DX	36	1,97
23	F	67	90	184	ant.t.	DX	27,4	2,13
24	F	67	78	172	post.t.	SN	39	1,91
25	F	68	73	163	post.t.	SN	35	1,79
26	F	68	60	165	poplit.	SN	21	1,66
27	F	69	52	157	ant.t.	DX	24	1,51
28	F	71	64	168	ant.t.	DX	18,3	1,73
29	F	72	57	164	peron.	SN	69	1,62
30	F	74	56	163	ant.t.	DX	43	1,60
31	F	74	63	160	post.t.	DX	55,3	1,66
32	F	76	60	168	peron.	SN	42	1,68
33	F	76	63	156	post.t.	SN	67	1,63
34	F	78	67	167	poplit.	SN	34,2	1,75
35	F	79	60	165	ant.t.	DX	49	1,66
36	F	79	63	169	post.t.	DX	38	1,72
37	F	80	59	157	peron.	DX	46,2	1,59
38	F	81	57	163	poplit.	DX	35,2	1,61
39	F	82	66	168	post.t.	SN	61,2	1,75
40	F	83	57	163	ant.t.	SN	41	1,61
mean		75	72,93	68,68				
sd ±		4,5	9,3247	8,034				0,16

CONCLUSIONS AND DISCUSSION

The study of the development of collateral circles and the definition of their patterns has a great clinical importance both for prognosis and for therapy, allowing best choice of time and type of surgical intervention. As the arteriopathy progresses, the arterial stenosis/occlusion determines an increase in lood flow through the hif resistence vessels. This phenomenon causes a reduction of the pulsatory wave and of the average arterial pressure downstream (Carter, 1978). The Windsor index is a valid measurement of the hemodynamic significance of a stenosis, and allow the assessment of the adequacy of a compensatory circle. Indeed, the anatomical and hemodinamic state of the lower limb is the most important predictor of surgical revascularization outcome (Malan and Tattoni, 1963).

In our cases, the tibialis as. were the vessels most often involved in arterial occlusion (posterior tibialis a., 15 cases = 37.5%, posterior tibialis a., 12 cases = 30%), followed by the peroneal a. (8 cases = 20%) and by the popliteal a. (5 cases, 12.5%).

The highest hemodynamic impact was found in popliteal occlusions, while occlusions of the anterior tibialis a., of the peroneal a., and of the posterior tibialis a., showed progressively lower hemodynamic compromission. The low hemodynamic compensation provided in occlusions of the popliteal a. is explained by the small caliber of the vessels that can be involved in the collateral circulation. This is in agreement with the notion that the collateral circles that develop following a popliteal occlusion can ensure an adequate perfusion of the leg only occasionally. Indeed, the occlusion of the popliteal a expecially when it developes acutely or subacutely, has often an unfavourable outcome. On the opposite when the posterior tibialis a. is occluded the collateral circles established through the great anastomotic a. and through the anterior tibialis a. and the peroneal a. are often adequate in restoring hemodynamic compensation, as shown in our study (mean IW = 55.44%). The same is true also for the collateral circulation in the occlusions of the peroneal a. (mean IW = 44.71), which developes from both the anterior and posterior tibialis as. Finally, the scarce efficacy of hemodinamic compensation in occlusion of the anterior tibialis a. (mean IW = 35.48%) may in part be explained by the type of collateral circulation (transversal-perpendicular) from the posterior tibialis and peroneal as., and in part by the smaller caliber of this artery compared with the posterior tibialis a. Comparing the hemodynamic significance of occlusions at each level between sexes, the differences were slight and not significant. This result suggests the hypothesis that with aging the gender differences in muscular development, vessel caliber and risk factors for atherosclerosis tend to become balanced, in agreement with the comparable incidence of coronary heart disease in men and women above age 65 (see Coronary heart disease incidence, by sex - US, 1971-1987, 1992).

The combined use of CA and CDE applied in this study has allowed an accurate description of collateral circles following distal lower limb arterial occlusions, with a measure of their hemodynamic adequacy. As the guidelines for therapeutical interventions and, eventually, for the type of prosthesis to apply have not yet been fully developed (Stipa, 1977, Sauvage and Berger, 1974), this approach may prove useful for the identification of surgical indications based on the patterns and hemodynamic impact of the collateral circulation.

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